REPORT OF THE BOTANIST.

1887.

SIR: The subjects which have largely occupied the attention of this division during the past year are—

First. An investigation of the grasses of the arid districts of the West and Southwest, concerning which a bulletin has been published. Two agents were employed in the examination in western Texas, New Mexico, Arizona, and parts of Nevada and Utah. Some two hundred species of grasses were observed growing in different situations and soils, and about thirty of these have been selected as deserving of attention and experiment for purposes of cultivation. Figures and descriptions of these are given in the bulletin in order to facilitate an acquaintance with them by persons interested, and it is hoped that a careful trial will be made of such by the farmers and graziers of the district.

Second. Several new or interesting and promising forage plants have been brought to the attention of the Department as presenting promising features for cultivation in special localities. Among these are some species of clover, and a European forage plant known as Sainfoin or Asperset (botanically, *Onobrychis sativa*), which has attracted, recently, considerable attention in California and Nevada as giving promise of great value for cultivation on dry hills and mountain slopes.

A paper on *Teosinte* as a forage grass is also presented. On account of the large quantity of foliage which this grass affords, it has great value for soiling and storing in silos wherever the climate will allow of its full development.

Third. We have continued an account of common weeds which interfere with agriculture, and have given such information respecting their destruction and eradication as we have been able to obtain. In addition, some account is given of the cultivation of Peppermint for the purpose of procuring the oil for medicinal and pharmaceutical purposes.

A paper on cross-fertilization and another on pollination are also presented, which will provoke research and investigation.

Respectfully,

GEO. VASEY,
Botanist.

Hon. N. J. COLMAN.

FORAGE PLANTS.

TEOSINTE (*Euchlæna luxurians*).

This new forage plant, a native of Central America, bids fair to fill a permanent place for the South. Seed was first introduced into this country by the Department many years ago, but not until 1886 is there any record of its having ripened seed in the United States. In that year a small quantity was ripened in southern Florida and

in southern Mississippi, near the Gulf. In the fall of 1887 circulars were sent to a number of parties to whom seed had been distributed the preceding spring, asking whether any of the plants had ripened seed; also that samples of the growth be sent to the Department. Samples bearing ripe seed were received from several parties in southern Florida, but from no other locality. On one of the stalks, having 13 fertile joints, 812 seeds were counted. In some cases ripe seed was produced on plants the seed of which was planted the preceding spring, but usually it was produced on those the roots of which had lived through the previous winter, Teosinte having been cultivated for a number of years in that section. A quantity of the crop of seed which ripened in southern Florida the past season has been purchased by the Department to be distributed in the spring of 1888.

Teosinte makes a rapid, succulent, and abundant growth, which, in the warmer parts of the country, may be cut two or more times during the season. In Florida the first crop from roots which have lived over winter is sometimes cut for fodder, and the second crop left to ripen seed. This plant requires good soil, and that which is moist but not necessarily wet. It can not be considered of any value for the dry regions of the West, except where irrigation is practiced. It seems to suffer from the effects of drought rather more than Indian corn. On good soil which is not too dry it will probably prove to be of value much farther north than where it attains its complete development. On good garden soil on the Department grounds plants from seed sown on the 4th of last June attained a height of 6 feet by the 29th of July.

A sample of Teosinte grown in 1885 by John S. Erwin, of Kirkville, Mo., was analyzed by Mr. Edgar Richards, of the Chemical Division of this Department, and found to contain a lower percentage of crude fiber and a higher percentage of albuminoids than either clover or timothy hay. Mr. Clifford Richardson, the acting Chemist, expressed the opinion, however, that the sample was exceptionally rich. (Plate I.)

WHITE SAGE (*Eurotia lanata*).

This plant, known as "White Sage" or "Winter Fat," is abundant in places through the Rocky Mountain region from Mexico to British America. Prof. S. M. Tracy, who visited portions of Nevada, Arizona, and adjoining territory in 1887, investigating the native forage plants under the direction of the Commissioner of Agriculture, states that in more arid districts of Arizona, Nevada, and Utah this plant, with Greasewood (*Sarcobatus vermiculatus*), are the most highly valued plants for winter forage. An important fact in regard to the plant is its ability to thrive in somewhat alkaline soils. It is employed as a remedy for intermittent fevers.

It is a perennial, half shrubby plant growing a foot or two high, with slender wooly twigs, which are abundantly covered with linear sessile leaves an inch to an inch and a half long, with a velvety surface of a grayish color and with the margin rolled back. They are mostly in small fascicles or clusters. The flowers are minute and in small clusters in the axils of the leaves, chiefly on the upper part of the stem. The flowers are of two kinds, male and female, on separate parts of the stems, or sometimes on separate plants. The small fruit is covered with long and close whitish hairs.

The plant belongs to the order *Chenopodiaceæ*, or the same order as the common Pigweed. (Plate II.)

NOPAL OR CACTUS (*Opuntia Engelmanni*).

One of the principal characteristics of the vegetation of arid districts is the prevalence of different species of *Cactaceæ*, or cactus-like plants. These are exceedingly variable in form and size, and are divided into several genera. Of these the Opuntias are extremely common. There are two kinds of these; one with broad, flat joints, and one with cylindrical or club-shaped joints.

Of the flat, broad-jointed kind there are many species. The *Opuntia vulgaris* is common in sandy ground in the Eastern Atlantic States. In western Texas and other parts of the arid regions reaching to California is a much larger kind, of the same general appearance, which is called *Opuntia Engelmanni*. This is a stout, coarse-looking plant, growing from 4 to 6 feet high, and much branched. The joints are, in large specimens, a foot long and 9 or 10 inches broad, with groups of stout spines from one-half to 1½ inches long. They are apparently leafless, but in young specimens minute fleshy leaves may be detected. Springing from the side of these joints at the proper season are handsome flowers 2 or 3 inches in diameter, which are succeeded by a roundish fruit, nearly 2 inches long, filled with a purplish pulp, generally of an insipid taste, while imbedded in the pulp are numbers of hard, small seeds. The common name of this Opuntia among the Mexicans is Nopal, and some of the species have fruit which is edible and highly esteemed. The use of the above species of Prickly Pear or Cactus for forage in the dry regions of Texas and westward is a matter of considerable importance. An extended account of its use is given in Bulletin 3 of this division. The usual method of preparing the plant for feeding is to singe the prickles over a brisk blaze. To some extent, especially by sheep, the plant is eaten in the natural state, but serious consequences frequently result in such cases. Its chief use is as a substitute for other fodder in times of scarcity, but when properly prepared and fed with hay and grain it forms a valuable article of food for cattle. (Plate III.)

SAINFOIN (*Onobrychis sativa*, Lam.).

This leguminous forage plant has recently been introduced into this country under the name of "Asperset."

Esparsette is the German name; Sainfoin is the name used in France and England. It is a perennial, having somewhat the appearance of Lucerne, but of smaller size and different habit. It seldom exceeds 1½ feet in height, with a weak stem, rather long, pinnate leaves, and flowers of a pink color in a loose spike, 2 to 4 inches in length, raised on a long, naked peduncle or stalk. The flowers are succeeded by short, single-seeded pods, which are strongly reticulated or marked by raised lines and depressed pits. It is a native of central and southern Europe and western Asia, and in Europe has long been in cultivation. From experiments made by the Duke of Bedford in England we learn that it was first introduced to English farmers as a plant for cultivation from Flanders and France, where it has been long cultivated. It was found to be less productive than the broad-leaved clovers, but on chalky and gravelly soils there was abundant proof of the superiority of Sainfoin. It produces but little herbage the first year, but improves in quantity for several years.

Mr. Martin J. Sutton, in a recent work on "Permanent and temporary pastures," says that it has been cultivated in England for over two hundred years. He says that it is essentially a food for sheep, and in pasturing the sheep do it no injury. It is also useful for horses, but produces nothing like the quantity of green fodder that can be obtained from the Lucerne patch. When sown alone Mr. Sutton says that Sainfoin is liable to decrease and become overrun with weeds. He recommends its use as a predominant constituent in a mixture of grasses and clovers. He says that combined with strong growing grasses there is less risk and the grasses keep down the weeds which otherwise are apt to overrun the Sainfoin. In a green state it is quite free from the danger of blowing cattle (Hoven), and when made into hay is an admirable and nutritious food. But it requires great care in drying when made into hay.

Mr. Sinclair states that the produce of Sainfoin on a clayey loam with a sandy subsoil is greater than on a sandy or gravelly soil resting upon clay.

A French writer says that Sainfoin can not accommodate itself to damp soil, and even dreads soil which, although dry, rests upon a wet subsoil. It delights in dry soil, somewhat gravelly and, above all, calcareous. It flourishes upon the declivities of hills where water can not remain, and in light soil where its powerful root can readily penetrate. But, although surviving in the poorest calcareous soil, like clover and Lucerne, its productiveness is always relative to the permeability and fertility of the land. It prefers open, sunny places, with a southern or eastern exposure.

Sainfoin has received several trials in this country, but without much success, probably from the experiments having been made upon unsuitable soil. We can not expect that it will be preferred in places where clover succeeds, but in light soils and in regions with a light rain-fall it should receive a thorough trial.

A recent bulletin of the Iowa Agricultural College gives the result of some experiments with this plant, which are very satisfactory. Observations there made indicate that it stands early freezing quite as well as Kentucky blue-grass. It produces at the rate of 3 tons of dry hay per acre. It deserves trial in Kansas, Nebraska, and Colorado. (Plate IV.)

ALSIKE CLOVER (*Trifolium hybridum*, L.).

This differs from common red clover in being later, taller, more slender and succulent. The flower heads are upon long pedicels, and are intermediate in size and color between those of white and red clover. Its botanical name was so given from its being supposed by Linnæus to be a hybrid between those clovers, but it is now known to be a distinct species. It is found native over a large part of Europe, and was first cultivated in Sweden, deriving its common name from the village of Syke in that country. In 1834 it was taken to England, and in 1854 to Germany, where it is largely grown, not only for its excellent forage but also for its seed, which commands a high price. In France it is little grown as yet, and is frequently confounded with the less productive *Trifolium elegans*.

The following is condensed from "Les Prairies Artificielles" by Ed. Vianne, of Paris:

> Alsike does not attain its full development under two or three years, and should therefore be mixed with some other plant for permanent meadows. It is best adapted to cool, damp, calcareous soil, and gives good results upon reclaimed marshes.

It is adapted neither to very dry soils nor to those where there is stagnant water. Being of slender growth, rye-grass, rye, or oats are often sown with it, when it is to be mowed. In fertile ground weeds are apt to diminish the yield after a few years, so that it requires to be broken up. It is generally sown in May, at the rate of 6 to 7 pounds of the clean seed per acre. Sometimes it is sown in the pods at the rate of 50 to 100 pounds per acre either in spring or in autumn after the cereals are harvested.

Alsike sprouts but little after cutting, and therefore produces but one crop and one pasturage. The yield of seed is usually 130 to 170 pounds per acre. The seed separates more easily from the pods than that of ordinary clover, and as the heads easily break off when dry, care is required in harvesting.

It does not endure drought as well as the common red clover, but will grow on more damp and heavy soils, and it is said that it can be grown on land which, through long cultivation of the common clover, has become "clover sick."

(Plate V.)

French clover (*Trifolium incarnatum*).

This annual clover is a native of Europe. It grows to the height of about 2 feet. The heads are about 2 inches long, very densely flowered, with the petals varying from a pinkish to a crimson color. It has been introduced and tried to some extent for cultivation in this country, but has not met with much favor. It deserves trial, however, in the dry climate of the West. (Plate XIV.)

Mammoth clover (*Trifolium medium*).

The true botanical position of the clovers cultivated in this country under the names Mammoth, Sapling, or Pea-vine clover, etc., is still somewhat in doubt. They are usually regarded as being the above-mentioned species, but are, perhaps, a variety or varieties of the common red clover, *Trifolium pratense*. They agree in having a larger and later growth than the ordinary red clover, and on this account are for some purposes more valuable.

The following records of experience may be relied upon for the localities mentioned:

Prof. Samuel Johnson, Agricultural College, Michigan:

It grows too rank and coarse to make good hay. For pasture or for manurial purposes it might prove better than the smaller sort. When grown for seed it is usually pastured until the 1st of June, and then allowed to grow up and mature the crop.

M. C. Alger, Augusta, Mich.:

Pasturing until the 1st of June insures a larger yield of seed, as it is cooler while filling; but many do not pasture. I do not think it can be cut more years than the smaller kind. It is said to stand drought better, but I doubt that. It will give three times the amount of pasture during the season that is given of the smaller kind if kept down pretty close, but during the fall the amount of pasture produced is less. It is said to smother out in winter if a large amount is left on the ground. Another objection is that it requires cutting just at harvest time.

C. M. Alger, Newaygo, Mich.:

I have raised the Mammoth Clover, but do not like it for my heavy land, as it grows too large. For every acre that I raise I have to buy or borrow two more of my neighbor's to cure it on. It is, however, excellent for pasture, as it stays on the ground longer than the medium variety. It is good for raising seed, as it nearly always fills full. I have seen 8 bushels per acre. The seed is always grown on the first crop, as the second never blossoms. It grows here from 4 to 5 feet high and is good for plowing under for manure.

Austin Pots, Galesburgh, Mich.:

Perhaps not over 20 per cent. of the clover grown here is of the mammoth variety. It does not seed as well as the common clover.

L. H. Bursley, Jenisonville, Mich.:

I do not find it as good for hay as the common red clover; the stalk is so large that stock will not eat them at all. For pasture it is better than the small variety. It does not require pasturing in spring in order to produce a crop of seed.

James Hendricks, Albany, N. Y.:

About twenty years ago there was treble the quantity sown in this part of Albany County that there is at present; now nearly all our farmers sow the medium clover with timothy.

Prof. F. A. Gully, Agricultural College, Miss.:

On good land with us it grows rank, and the long stems fall down and mat on the ground, and if we happen to have wet weather the lower leaves and parts of the stalk will begin to decay before the plant is in full bloom. The second crop ripens seed, but to what extent I can not say. I consider the common red clover more desirable here, although it may not yield as well.

WEEDS OF AGRICULTURE.

The following account of the more troublesome weeds is continued from the report of last year:

Purslane (*Portulaca oleracea*).

A low prostrate annual, common in cultivated grounds, with thick, fleshy, obovate leaves, about an inch in length, and very smooth. The flowers are minute and sessile at the ends of the branches and in the axils of the leaves, opening only in the morning sun; the five or six petals are pale yellow, the stamens number seven to ten and twelve, and the capsule or seed vessel is oval, and opens by the rupture of a transverse seam near the middle. This introduced weed is everywhere known in this country by the name of Purslane or "Pusley."

In the cooler climate of England it is not considered a weed, and is used to some extent as a pot-herb. It does not start into growth until the season is well advanced, in the Northern States about July. It is most troublesome in garden crops, such as onions, and does comparatively little harm in such crops as corn and potatoes, which shade the ground and permit horse cultivation. It is most prevalent on sandy soils. Its troublesomeness results mainly from its prolificacy and rapid maturity, and from the fact that it will retain its vitality and mature its seed after being detached from the soil. If the land is repeatedly cultivated before the plant exceeds an inch in height it is easily kept down, but if allowed to become large it is almost certain to ripen its seed. After garden soil has become stocked with the seed it will often be found best to cultivate the land in some field crop for two or three years, until it is freed from the weed, and grow the garden crops upon land which has not yet become infested.

The amount of seed produced may be judged from the fact that 1,250,000 seeds have been counted on a single plant. The greatest injury from this weed arises from the fact that it grows rapidly and ripens its seed after cultivation of the crops has usually ceased. (Plate VI.)

COMMON MILKWEED (*Asclepias cornuti*).

An herbaceous plant with a perennial root, native of this country, although now spontaneous in many parts of Europe. The stems are erect and unbranched 2 or 3 feet high, and clothed with opposite oblong leaves, with very short stalks, 4 or 6 inches long and with entire margins, soft and velvety on the lower side, with many prominent veins at right angles with the midrib, and connecting near the margin. The flowers are in large clusters, called umbels, proceeding from the top and upper portion of the stem, each umbel supported on a thickish peduncle 2 to 4 inches in length. The individual flowers, 20 to 40 in each cluster, are supported on slender pedicels about an inch in length. The flowers are less than half an inch long and of the peculiar structure common to the milkweed family. This will be best explained by reference to the figure given. Usually only one or two of these flowers mature fruit, which is an ovate pod about 3 inches long and an inch thick, roughish, with weak protuberances, but soft and velvety, and filled with a multitude of small flat overlapping seeds, each with a crown of soft silky fibers, which seems to waft the seed in the air.

This best known of our milkweeds, north of Tennessee and east of the Mississippi, has become exceedingly troublesome in some localities as a weed. Its deep running perennial root-stocks are very tenacious of life, and spread rapidly, throwing up numerous stems. The plant is most troublesome in meadows and along roadsides, forming patches which check the growth of grass. Its seeds are distributed by means of a tuft of silky hairs. The milky juice is a popular remedy with children for warts. The young shoots are used by some as a substitute for asparagus. The plant has a strong fiber, which some have attempted to utilize.

This plant is subject in some localities to the attacks of a fungus, which checks its growth and gives it a sickly yellow appearance. The affected leaves usually become revolute at the margin, and the plants, if badly affected, fail to blossom, and send up numerous slender shoots, reminding one of the "yellows" in peaches. The extermination of the plant requires careful cultivation throughout the entire season, after which it will not be found difficult to prevent its becoming again established. (Plate VII.)

CURSED CROWFOOT (*Ranunculus sceleratus*).

A low herbaceous plant of the Buttercup family with a smooth, thickish, spongy stem, much branched above. The lower leaves are one-half inch in diameter, deeply three-lobed, with the lobes coarsely and obtusely toothed; the upper leaves become narrower and less divided, or almost linear and undivided. The flowers are very numerous and small, on pedicels half an inch to an inch in length. The light yellow petals are less than one-fourth inch in length. The heads of carpels or fruit are, when mature, about half an inch long, densely crowded with the minute seeds. The plant attains a height of a foot or two. It is a native of Europe, but has been widely distributed over the world. It is found mainly in ditches and other wet places. The name was not given by reason of any extreme troublesomeness as a weed, but on account of the acrid and biting character of the juice. This is so irritating that if applied to the skin it will readily produce blisters. Notwithstanding this fact, if

the plant be boiled and the water thrown off, it is not unwholesome, and is sometimes eaten by the peasants in Germany as a vegetable. (Plate VIII.)

Chondrilla juncea.

This plant grows to the height of 2 or 3 feet, having strong, deeply spreading roots, and slender, twig-like stems, more or less branching above and apparently destitute of leaves, or with a few slender thread-like leaves. The leaves are mostly in a cluster at the base of the stem, where they have an irregular jagged shape, much like those of the Dandelion. The bare twigs become sparingly clothed during the summer with sessile flowers of the order *Compositæ;* in appearance much like those of Lettuce. This unsightly perennial weed has been introduced into Maryland, Virginia, and other Southern States, where it is spreading along roadsides and over dry uncultivated fields. Complaints have been received from Virginia of its agressive nature, and of the difficulty of its extermination. It is a native of the southern half of Europe and the adjoining countries of Asia. Over most of France it is common upon sandy soils. It has not yet entered England and the other northern countries of Europe, and therefore it is not expected that it will become prevalent to any extent in our Northern States.

For the eradication of this pest summer fallowing with frequent plowing and harrowing will be necessary. This method, succeeded by a hoed crop, will probably relieve the field of its presence. At the same time the greatest care should be taken to exterminate it from roadsides and neglected fields, where it is liable to maintain a foothold. (Plate IX.)

ST. JOHN'S WORT (*Hypericum perforatum*).

A perennial herb, growing 1½ to 2 feet high, usually with many opposite spreading branches, and clothed with many opposite, small, sessile leaves, less than an inch long, oblong or ovate-oblong, with entire margin and obtuse summit. These leaves are marked by many minute pellucid dots. The flowers are collected into small clusters or cymes at the extremity of the branches. They are less than an inch in diameter, with five deep yellow petals, which are twice as long as the lanceolate sepals. The stamens are very numerous, collected in several clusters. There are three pistils, which develop into a three-celled many-seeded pod.

This plant received its name, probably, from the fact that "the common people of France and Germany gather it with great ceremony upon St. John's day and hang it in their windows as a charm against storms, thunder, and evil spirits." The plant has been introduced and become naturalized quite extensively in this country east of the Mississippi. It is a perennial weed, rather troublesome in old fields and pastures. At one time it was supposed to cause ulcers upon the feet of cattle, but it has probably no such effect. (Plate X.)

PIGWEED (*Amarantus hybridus*).

This coarse annual weed, common in nearly all cultivated ground, grows to the height of 4 or 5 feet, with a much-branched stem, with numerous alternate leaves, which are mostly from 2 to 3 inches long,

of an ovate form, with prominent nerves and entire margins. The flowers are small, of a pale-green color, and very numerous in terminal and lateral spikes. Each minute flower has at the base three stiff, pungent bracts, with five thin, chaffy sepals, five stamens shorter than the sepals, and a central ovary or seed vessel containing a solitary black and shining seed. In some cases these flowers contain only stamens, and in others only the pistillate organs. The "Lamb's Quarters" or Goosefoot (*Chenopodium album*) is also known in common language as Pigweed. In some sections it is conveniently distinguished from that weed by the appropriate name of "Red Root."

The species here described and illustrated seems to be the one most abundant in cultivated grounds in this country. Like the other closely-related species which have become weeds, it is an introduction from the warmer parts of America or from Europe.

It is found abundantly native in Mexico and throughout the southern borders of the United States.

In Mexico and southern California the Amaranths are often used as forage plants, and the seed is gathered by the Indians for making bread. (Plate XI.)

Wild carrot (*Daucus carota*).

This biennial vegetable is so well known in its cultivated state in gardens as to hardly need any special description. It belongs to the Order *Umbelliferæ*, which is distinguished by having its small flowers in clusters, called umbels, so named because the flower stalks all start from one point at the extremity of a branch and spread out like the ribs of an umbrella. These stalks or rays, as they are called, are in most species again divided into smaller umbels called umbellets. In the Carrot these rays are very numerous, and form together a close flat-topped cluster, becoming concave in fruit. The leaves are divided and subdivided into numerous fine segments.

The Wild Carrot is abundant in several of the Central and Eastern States, and is spreading into new localities. It is not troublesome in cultivated land, being confined chiefly to meadows and roadsides. It is usually introduced in grass or clover seed. The umbels curl up when ripe and hold the seed into the winter, when it is gradually scattered; sometimes the umbels break off and are driven over the snow, carrying the seeds to adjoining fields. Fifty thousand seeds have been counted on a plant of average size. Carefully cutting the plants for two years will eradicate most of them. (Plate XII.)

Coco or nut-grass (*Cyperus rotundus*, var. *Hydra*).

This so-called grass, a species of Cyperus or Sedge, is regarded as the worst pest of agriculture upon sandy soils throughout the South. It is said to have been accidentally brought to this country by a gentleman of New Orleans among some exotics obtained from Cuba. Thinking that he had obtained some rare plant he set it in his garden and thus introduced this terrible scourge. It produces but little seed, but propogates itself mainly by runners which ramify through the soil, producing tubers at intervals of 6 or 8 inches and sending up stems to the surface. It is exceedingly tenacious of life and ordinary plowing and cultivation serves only to make it spread more rapidly. "The only process yet discovered by which this grass

can be extirpated is to plow or hoe the spots in which it grows every day through the whole season. In their perpetual efforts to throw their leaves to the light the roots become exhausted and perish."

It is said also that by planting the land to Bermuda grass the Nut-grass may be smothered out. Its appearance is well represented in the figure.

A correspondent of the Times-Democrat thus describes his experience with this pest:

I had a few acres thickly infested with nut-grass and determined, if possible, to get rid of this unwelcome interloper. Broke the land deeply in the fall, gave it a shallow plowing the following spring, and planted in cotton early in April. I cultivated it as well as I could, but it seemed almost impossible to keep ahead of the grass. About August 15, I took the turning plow, wrapped the grass up completely, and did not allow it to go to seed. I can not explain how it is, bnt my coco has disappeared and I am troubled with it no longer.

(Plate XIII.)

BARBERRY (*Berberis vulgaris*).

This shrub is a native of Europe, but has been introduced into the United States; is frequently seen in cultivation, and in New England has in some places escaped and become wild. It is a pretty ornamental shrub, attaining a height of 8 to 10 feet. The twigs are commonly spiny, and the leaves, which are obovate and sharply toothed on the margins, are in fascicles in close connection with the spines. The flowers are in racemes, like those of the currant, are of a yellow color, and are succeeded by bright red, oblong, acid berries. The berries are often used in making preserves for the table.

The shrub is brought to notice, not because it has yet become so common as to be called a weed, but principally because of the common but fallacious belief among farmers that the presence of this bush was the cause of rust in grain. This opinion arose from the fact that the leaves of the Barberry are subject to the attack of a fungus which is identical with one of the stages of the wheat rust, but has no necessary connection with it. (Plate XV).

MEDICINAL PLANTS.

PEPPERMINT (*Mentha piperita*, L.).

Numerous requests for information regarding the cultivation of peppermint have been answered by the division during the past year. About four-fifths of the world's supply of peppermint oil is produced in this country, the annual product amounting to nearly $1,000,000.

In addition to information given on this subject in former reports the following from Mr. P. F. Hagenbuch, a successful peppermint-grower of Saint Joseph County, Mich., has been furnished by request:

To grow mint successfully requires a good, heavy, sandy loam and clean culture. Cleanliness is essential for two reasons: First, mint is a slow-growing plant, and if it is not kept clean it is soon overgrown; second, mint-oil, when pure, has a very fine flavor, while if any of the weeds known as mare-tail, fire-weed, smart-weed, or rag-weed are distilled with the mint it acquires an offensive odor, which prevents it selling readily.

Mint has been carried from this county into other States, but usually with poor success. It has proved a failure in California, Iowa, Illinois, and southern Minnesota, the plant having a large growth but little oil.

I understand that it grows with success on sandy loam in northern Minnesota; also that it has been taken to Mississippi and grown successfully there.

I believe peppermint is the most successful crop that can be grown upon the marsh mucks of Michigan. Last year my partner and myself grew $400 worth of oil upon 9 acres, and we have 25 acres now ready to plant. Our marsh is tiled every 6 rods, from 3 to 4 feet deep.

Mint must be planted in the spring as soon as it is possible to get upon the ground, as the roots start very early. We generally plant on clean clover sod, corn stubble, or old potato ground. It is the only crop that I know of that follows potatoes well. After the ground is plowed and harrowed it is marked out one way, from 2 feet 8 inches to 3 feet apart, with a shovel plow, care being taken to make but a short distance ahead of the planting, that the land may be fresh. In digging the roots for planting we first plow them out, then shake well with a fork and draw in piles to where they are to be planted, covering well with earth to keep them from becoming dry. In planting, a man takes a coffee-sack and fills it with roots well picked to pieces, then swings it across his shoulder; he now gets astride of the row, pulls the roots from the sack with his left hand, throws them into the furrow with his right, and kicks the earth over them from both sides with his feet. An old hand at the work can plant an acre a day, but a green hand can not make all fours go at once, and will not plant more than half an acre. Care should be taken to always keep good roots in the row and have no gaps. After planting comes the hoeing and cultivating, which must be done with great care. If the land is reasonably clean at first, this can be done at a cost of $4 or $5 dollars per acre for the season, but in foul grassy land I have known a man to hoe only a tenth of an acre a day.

About the last of July the plants begin to throw out runners and cultivation stops. The blossoms appear in the latter part of August, and the crop is then ready to distil. A distillery will cost $200 or more, according to the cost of boiler. A distillery consists of a boiler (15-horse capacity), two large tubs, 6 feet high and 5 feet 10 inches across the top, and a condenser made of tin pipes. The steam, admitted at the bottom of the tub, goes up through the mint and comes out at the top with the vapor of the oil; the vapors of both then pass into the condenser, upon which cold water is pumped, the condensed steam and oil running out below into a receiver, which resembles an old sprinkling can. The oil remains at the top in the can, and the water is drawn off below. We usually cut the mint far enough ahead to have it dry before distilling, as it then handles better and loses no oil in drying. Peppermint is more reliable to grow than spearmint, as the latter is more delicate, being very sensitive to drought, too much moisture, or frost; in fact, a hard frost will often diminish the yield of oil one-half.

EVENING PRIMROSE (*Œnothera biennis*).

Mr. L. J. Germain, of Cuyahoga Falls, Ohio, has contributed a very full account of the medicinal properties of this plant, of which the following is an abstract:

In some of the Eastern States it is said to be used as a diaphoretic in fevers, and is there known as "fever plant." It is also said to be used there in the harvest field under the name of "coffee plant," for its invigorating qualities, and to slaken thirst and promote perspiration. In the Middle States it is generally known as "scabish plant," or wild Evening Primrose, and is in great repute for "summer complaints," such as ordinary diarrhea, cholera morbus, bloody flux, Asiatic cholera, cholera infantum, etc. The young roots are also grated fine, pulverized, or macerated with fresh lard, mutton tallow, or fresh butter, and applied as an unguent to cutaneous affections, such as burns, scalds, felons, bunions, erysipelas, cuts, and bruises. In the Southern States it is commonly known as "king's cure-all," and used by physicians to dispel gathering humors, such as boils or "gatherings." The negroes use it as an antitode for snake bites and as a poultice for wounds, causing them to heal by "first intention." For the latter purpose the usual method of preparing the poultice by country physicians is by boiling the leaves with wheat bran.

Another use for the plant is in cases of sun-stroke. Its reviving effect in such cases and the relief of the attending apoplexy is wonderful, as I have experienced in my own person and observed in others. It is also used as a soothing stimulant by the aged, infirm, and hypochondriacal. I have seen the tea used successfully to promote perspiration and check vomiting and spasms in a case of Asiatic cholera. I also used the same with good effect upon myself on one occasion in a case of ordinary cholera. On frequent occasions, during a series of years with a surveying party in the West, I have given it to my men for sudden attacks of bowel complaint, always with good results. In some cases better results seem to have been obtained

by a slight addition of alcohol to effect a more complete solution of some of the gummy principles. Sulphate of ether, instead of alcohol, has been used in desperate cases of cholera infantum and for the diarrhea which often follows scarlet fever.

I should also add that the blossoms placed in water form a mucilage excellent for inflamed eyes.

IMMEDIATE INFLUENCE OF CROSS-FERTILIZATION UPON THE FRUIT.

By A. A. CROZIER, *Assistant Botanist.*

This subject has received renewed attention from horticulturists and others during the last few years, and has been an object of experiment by private growers and at several of the agricultural colleges and experiment stations. It is a question of considerable practical importance. If different varieties of plants growing together may affect directly the character of each other's fruits, the fact should be definitely known and the extent of such influence determined. From the evidence collected it appears that many growers believe that in at least some cases such an influence exists. Squashes and pumpkins, for example, are believed to affect melons growing in their vicinity. In certain sections it has been the practice of market gardeners to plant an occasional hill of pumpkins in their fields of water-melons for the purpose of increasing the size and firmness of the melons for market. Among strawberry-growers it is widely believed that the berries of pistillate varieties will vary in character according to the staminate variety which furnishes the pollen. As many of the best varieties of strawberries are pistillate and require to be fertilized by some perfect flowered variety, it becomes important to know with certainty whether such an influence exists or not.

The question of the immediate influence of cross-fertilization upon the fruit has not heretofore received the attention of the Department. All the attainable evidence on the subject has therefore been collected both from growers and publications, and the principal portion of it, together with the results of a few additional experiments, is herewith printed. The total amount of existing testimony is considerable, but the amount of reliable evidence is small. The evidence here given, though sufficient, perhaps, to establish a probability, is intended mainly as a basis for a more complete study of the subject, which it is hoped will be made.

SUMMARY OF THE EVIDENCE.

Charles Darwin[8] gives a large amount of testimony to prove that cross-fertilization has an effect the first season upon the ovary or fruit as well as upon the seed; but he says that such an effect does not always follow, and that Mr. Knight, a careful observer, had never seen the fruit affected, though he had crossed thousands of apples and other fruits.

Dr. Asa Gray[9-12] contributes several articles on this subject to the American Journal of Science, and states that "it is generally agreed that the alteration of the character of the fruit is immediate, *i. e.*, that it affects the ovary itself," and adds: "Improbable as such an influence seems to be, it is hardly more so than the now authenticated fact that the graft of a variegated variety of a shrub or tree will slowly infect the stock."

Thomas Meehan, after publishing much on the subject in his Gardeners' Monthly,[19-22] reviews the whole question in an article in the

Rural New Yorker,[17] and concludes that there is not sufficient evidence to warrant a belief in the direct influence of pollen, except possibly in the case of Indian corn.

Mr. N. E. Hansen, a student at the Iowa Agricultural College, concludes from a large amount of testimony collected in 1887, and from some personal experiments, that foreign pollen does sometimes exert an immediate influence on the fruit.

The greatest amount of interest on the subject in this country has been in connection with the strawberry. Most growers who have given attention to the subject believe that there is a direct influence of foreign pollen, at least at times. At the last three sessions of the American Pomological Society the subject has been under discussion. Professor Lazenby, at the session of 1885,[2] reported experiments made in 1884 at the Ohio Experiment Station in which there was an apparently marked effect of foreign pollen upon the fruit of the strawberry. A repetition of the experiments in 1885, however, left the result in doubt.

In the same year[23] Mr. E. S. Goff, of the New York Experiment Station, crossed Crescent and Sharpless strawberries with other sorts and saw no influence of the cross. In 1886[24] he crossed the Crescent with pollen of three other varieties, but the fruit all appeared alike. In the same year he fertilized three varieties of black grapes with pollen of the white variety, Lady Washington, but observed no difference in the character of the resulting berries.

Thomas Wild, of Cooperville, Mich., has made numerous crosses in strawberries and believes that in some cases an influence of the cross is seen the first year. Perhaps the best evidences of immediate influence of foreign pollen is found in the case of corn. It will be borne in mind, however, that the ovary here is but a thin covering to the seed, and that any effect observed may be due solely to a change in the seed itself.

Mr. A. A. Crozier in 1879 crossed flint corn with Yellow Dent, and in 1886[5] crossed sweet corn and White Dent with Yellow Dent and observed an effect of the cross the same year.

Experiments at the U. S. Experiment Station by Dr. E. L. Sturtevant upon corn, though not undertaken for the purpose of determining this point, have satisfied him that there is an observable effect the first season.

Prof. S. M. Tracy states to the writer that he has crossed flint corn with yellow dent without observing any effect the first year. In other cases, however, an immediate effect has been seen.

Experiences like that recorded in the letter of D. M. Ferry & Co., given below, are so common that the general opinion that corn will "mix" the first year seems fairly well sustained.

Among *Cucurbitaceæ* it is generally believed that cross-fertilization readily occurs and that its effect appears in the fruit the first season. Pumpkins are supposed to influence the fruit of squashes growing in their vicinity; water-melons are thought to be especially liable to be injuried by citrons; and cucumbers have been said by good observers to affect the quality of muskmelons growing near.

In some experiments by M. Naudin,[10] a French scientist, on crossing in *Cucurbitaceæ*, the varieties in each species crossed readily and there seemed to be an effect the first season, but the species themselves refused to hybridize. Out of seventy trials between all the known species except one, in but five instances did the fruit set, and in none of these was there a perfect seed.

The letters of Mr. Baker and D. M. Ferry & Co., given below, together with the quotation from Mr. Darlington, are strong testimony in favor of an effect of a cross the first year. On the other hand, if such an effect exists, it is remarkable that such seedsmen as Messrs. Comstock, Kolb, and Henderson, as shown in their subjoined letters, have never observed it.

During the past season Professor Bailey,[4] Mr. Skeels,[25] and Mr. Crozier[6] each made successful crosses between different varieties of summer squashes, but the fruits differed in no observable respect from those self-fertilized.

In regard to the ordinary fruits the testimony is equally discordant. About 1873 Dr. B. D. Halsted and Mr. C. W. Garfield, under the direction of Dr. W. J. Beal, at the Michigan Agricultural College, made one hundred crosses between different varieties of apples. About twenty fruits were the result, some of which seemed to combine the characters of both parents. Both Dr. Halsted and Mr. Garfield believed at the time that these results were due to an influence of the pollen used. Dr. Halsted still holds to that opinion, but Mr. Garfield, in view of the variations which spontaneously appear among apples, now doubts whether the appearances then observed were due to the crossing.

Other experiments of the same nature have been made by students of Dr. Beal, but from none of them is he satisfied that there is an influence of a cross the first year.

In 1886 Dr. Halsted[15] crossed flowers of the Longfield apple with pollen of the Roman Stem. The resulting fruits combined the characters of both varieties and were believed to show a direct influence of the foreign pollen. Other crosses, made by himself and Prof. J. L. Budd at the Iowa Agricultural College, gave the same result.

In 1887 Prof. L. H. Bailey[4] crossed Hyslop crab with the Oldenburg apple, and another variety of crab with Sweet Romanite, but no change in the fruit was observed. He also crossed the Spiny-fruited *Datura stramonium* with pollen of the Smooth-fruited *Datura inermis* without observing any change in the character of the pods (see letter of Professor Bailey, given below). Among citrus fruits there is a prevalent belief in the immediate influence of cross-fertilization.

Mr. Hart, whose letter is given, and Mr. Lyman Phelps, of Sanford, Fla., believe that they have observed a change in the appearance of oranges due to the pollen of other varieties growing near. The Bahia, or Washington Navel orange is believed to be especially potent in impressing its peculiar mark upon other varieties; but as this variety produces very little pollen and is a shy bearer unless fertilized by other varieties, and as specimens having the Navel mark are found in varieties where no Navel trees exist, the evidence from this source for the immediate influence of pollen on the fruit does not seem to be conclusive. No direct experiments in the crossing of oranges to determine this point seem to have been made, though some are now in progress in the orange house of the Department of Agriculture. In the crosses between varieties of the orange which have been made by Mr. Saunders, superintendent of the Department grounds, and his assistants, no immediate influence has been observed.

A cross of a lemon with pollen of an orange was made the past season by Mr. Henry Pfister, head gardener at the Executive Mansion. The fruit is now (January, 1888) full size, and resembles the other lemons upon the same tree.

The following letters are given from among those received at the Department in response to inquiries upon this subject:

T. F. Baker, Bridgeton, N. J.:

In Maurice River and Fairfield Townships, Cumberland County, an occasional hill of pumpkins has been planted among water-melons, but not for the past three years. It increases the size very much, and also makes the rind harder, so that they endure handling and transportation better. The universal opinion of those who have practiced this method is that it had invariably a bad effect upon the quality, so that they have abandoned the practice.

There is ample evidence the first year of mixture, and seed from such stock is utterly worthless where good toothsome melons are desired.

Prof. L. H. Bailey, jr., Agricultural College, Mich.:

I have performed many crosses this year between such plants as would give unmistakable evidence of the immediate effect of pollen should such effect occur. I crossed Hyslop crab with Duchess of Oldenburg and got no effect in any way, not even in season of maturity or texture. I crossed another crab with Sweet Romanite and obtained no immediate effect.

By the way, I made a singular incidental experiment on these varieties. Of five crabs I removed four of the pistils and crossed the remaining one. From these crosses I got two mature apples, but they had seeds in only one cell.

I crossed many Crookneck squashes with the White Scallop or Summer Turban. The squashes are nearly mature, but there is no immediate effect whatever. In order to test the matter more fully I hybridized two plants which have exceedingly dissimilar fruits. These are *Datura stramonium* (Jamestown weed) and *D. inermis*. The former has very prickly pods, the latter very smooth ones. I have made reciprocal hybridizations, but there is no immediate effect of pollen. I have never yet seen any immediate effect of pollen. I am very careful in making my crosses, and I know that I have made no mistake. I do all the work myself I use manilla bags on both pistillate and staminate flowers, and I leave them on the pistillate flowers a week after the operation is performed.

Prof. J. L. Budd, Agricultural College, Ames, Iowa:

The most marked variation in the shape of fruit was in the crossing of the Roman Stem on the *Pyrus coronaria*. Some of the specimens were so like Roman Stem in shape and in the peculiar stem and basin as to be difficult to separate, except by color of skin and texture and flavor of flesh.

But we have had a number of essential changes where we have crossed remotely connected varieties and species. Roman Stem on the Russian Silken Leaf apple has given some peculiar changes of fruit.

Next year I will report more carefully. I have never doubted the possibility of a change of fruits in this way since I crossed the Colfax strawberry twenty-five years ago.

William G. Comstock, East Hartford, Conn.:

In all my experience, and I have been a practical seed-grower fifty years, I have never seen any mixture in the fruit the first year from cross-fertilization, but from seeds of the crossed specimens planted the next year fruits have been produced in which the mixture has been plainly shown. I never knew a melon to partake of the cucumber flavor or to show any spines. The smooth-stemmed squashes, like the Boston Marrow and Hubbard, do not mix with the rough angular-stemmed varieties like the Crookneck, nor with the field pumpkin.

William Darlington, in his work on American Weeds and Useful Plants, p. 142, says:

When growing in the immediate vicinity of squashes the fruit of this species (*Cucurbita pepo*, Pumpkin) is liable to be converted into a hybrid of little or no value. I have had a crop of pumpkins totally spoiled by inadvertently planting squashes among them, the fruit becoming very hard and warty, unfit for the table and unsafe to give to cattle.

F. S. Earle, Cobden, Ill., writes:

The question of the immediate influence of cross-fertilization is an important one, and I am glad you are investigating it. I think there is no question that the fruit of pistillate varieties of strawberries varies when fertilized by different staminate varieties, but I have always suspected that the more abundant pollen, and conse-

quent more perfect pollination afforded by some varieties, had quite as much to do with the difference in the result as any true effect of the cross-fertilization. Reliable experiments are badly needed on this subject, but I am sorry to say I have none to report. Practical fruit-growers are always too much rushed by work that can not be put off to conduct experiments with the care necessary to give them scientific value.

D. M. Ferry & Co., Detroit, Mich.:

Concerning the effect of cross-fertilization, we would say that whatever observations we have made have not been recorded and the attending circumstances carefully enough noted to make them of any value from a scientific point of view, but they have been extensive enough to convince us that very often, but not uniformly even in the same species and variety, the pollen does affect the developing fruit.

There is not a season but what we have experiences like this: A certain stock of sweet corn is divided between two or more growers. All but one of the fields grown from that are perfectly clear of any trace of field corn; but one corners on a field of field corn, and in that field, and very markedly on the side nearest the field corn, we find much mixture of yellow and crossed grains. If this was a result of previous impregnation why should it show itself in this field and in no other?

Similar results have been noticed in cucumbers, squashes, and water-melons; that is, a field near some other variety will have a greater or less number of melons which are clearly crossed, or "off type," but other fields planted from the same bag and not near other fields would seem perfectly pure.

Again, in 1883 and 1884 we made a large number of crosses between different varieties of peas, carefully emasculating the blossoms used, and had quite a number of pods of smooth and yellow-fruited varieties which had been fertilized by wrinkled sorts which would have the same pod peas of the normal type and color and others which were distinctly and very clearly wrinkled and of a green color.

Again, in the pickings from our crop of peas and beans which have been reported as grown too near other sorts we see a marked trace of the neighboring sort. We know it is claimed by some that peas and beans are self-fertilizing, but we have learned that they are not always so, to our cost. We are sorry we can not give you more explicit data, but have done what we could.

E. H. Hart, Federal Point, Fla.:

Among oranges the influence of cross-fertilization is constantly apparent. I have a number of trees of an imported variety of the orange called "Long," the fruit of which has always been extremely elongated. The row next to these was budded several years ago with a flat orange which bloomed and set fruit for the first time this season. The pollen of these flat oranges has modified the long oranges next to them to such a degree that the latter are nearly all round, and some of them flattened, a feature never before observed.

The Navel orange is one of the most potent to leave its marks on other kinds in its vicinity.

Peter Henderson, New York City, N. Y.:

We have cultivated on an acre of ground during the last twenty years an average of thirty varieties of strawberries, running side by side. Among these varieties some were pistillate, some staminate, and some having perfect flowers, and yet with the most careful observation I have never observed the slightest variation in the fruit from such a mixture of varieties. You say that it is generally believed in *Cucurbitaceæ* that a cross affects the fruit the first year, I have incontrovertible evidence that it does not. In our trial grounds, where probably fifty different species and varieties of *Cucurbitaceæ* are planted, so that we can examine the types, the closest observation has failed to show us a single instance where the fruit has been changed in the slightest degree. That the seeds of kinds so planted become mixed we well know, but the fruit proper is certainly never changed.

R. F. Kolb, Auburn, Ala.:

I have been growing melons for fifteen years, and am one of the largest growers in the South, my average crop being over 200 acres. There is never any evidence of mixing in the appearance of the fruit the first season, provided the seeds planted are perfectly pure and true to variety. You might plant two or more varieties of melons near each other, and if the seeds of each are perfectly pure when planted you would observe no mixing the first year in the appearance of the fruit, but if the seeds of either variety so planted were again planted the next season you would find among the crop various hybrids. In other words, the mixing goes into the seed the first year, but does not show itself in the appearance of the fruit.

Prof. James Troop, Purdue University, La Fayette, Ind.:

In regard to the immediate effect of cross-fertilization upon the fruit, I have tried the experiment here only on strawberries. Two years ago I tried it on several varieties, among them Crescent fertilized by Sharpless. I thought then that the sharp acid flavor of the Crescent was considerably toned down. This year my students tried the same thing, using Crescent for the female and Sharpless pollen, but we could not discover any change whatever in the flavor, size, or color.

While at Lansing, about 1881, I crossed Northern Spy and Golden Russet apples, crossing both ways, but the Spys were Spys, and the Russets remained the same as those on the rest of the tree.

I would hesitate to give an opinion either way until I have made further tests.

Hiram Sibley & Co., Chicago, Ill. (F. A. Warner):

As far as we have learned from information from our best growers here cross-fertilization does not appear during the first year.

The writer has known it in the case of corn not to appear in any marked degree until the second year, and with a certain knowledge that the cross was made during the year previous, as the planting of the seed the second year was too distant to have cross-fertilization occur.

CONCLUSION.

Considering all the testimony given above the writer is disposed to think that the evidence is still insufficient to show that there is an observable effect of a cross upon the ovary or fruit the first year, except in Indian corn, in which case his own observation will not permit him to doubt. It seems most reasonable to suppose that ordinary cases of apparent cross, observed where different varieties are grown together, are due to admixture of a previous year. It is admitted, however, that there are observations which can not be explained in this way. The occasional variations in the appearance of apples and other fruits, which have been supposed to indicate an immediate influence of pollen, have not been proved to be due to that cause. The argument from seedless fruits, which is sometimes made, seems inconclusive, for it has not been shown that fertilization is necessary to their production, though in numbers of other cases it has been proved that without fertilization no fruit matures. Even if true that the ovary, or even a larger portion of the plant, may be caused to develop by pollen without the intervention of the ovules, it requires better evidence than is yet offered to show that an immediate change in its character will result from the use of pollen of a different variety.

SUGGESTIONS FOR FUTURE EXPERIMENTS.

For those who may wish to experiment further on this subject the following suggestions are appended:

(1) Select varieties which you have reason to believe will readily cross.

(2) Select such as by their difference in form or color will readily show the effect of a cross if there be one.

(3) Use every precaution to prevent self-fertilization. To this end the selection, where practicable, of plants having separate sexes is desirable.

(4) For the same reason cover the crossed flowers for some time before and after fertilization with muslin or paper sacks, and exercise great care in applying the pollen.

(5) Mark plainly and securely the flowers experimented upon that there may be no mistake in the identity of the specimens when mature.

(6) Duplicate the experiments. The chances of failure are numerous, and there is continual danger of the loss of specimens up to the time of maturity. Errors of observation, and the liability of any observed change being due to other causes, are also greatly lessened by the multiplicity of specimens.

REFERENCES.

[The numbers correspond with those in the foregoing pages.]

1, 2, 3. American Pomological Society, Proceedings of, "Effect of Pollen on the Fruit," 1883, p. 38; "The Influence of Pollen on the Form, Size, Color and Flavor of the Fruit," 1885, p. 66; 1887, p. 21.

4. Bailey, L. H., "Notes on Crossing and Hybridizing," Bull. 31, Mich. Ag. Col., p. 90.

5, 6, 7. Crozier, A. A., "Immediate Influence of Pollen," Ag. Science, vol. 1, pp. 35, 227; "Influence of Cross-fertilization on the Fruit," Proc. Am. Pomological Society, 1887, p. 21; "Some Crosses in Corn," Proc. Society for the Promotion of Ag. Science, 1887, p. 91.

8. Darwin, Charles, "On the Direct or Immediate Action of the Male Element on the Mother Form," Animals and Plants under Domestication, vol. 1, p. 476.

9. Garfield, C. W., "Influence of Pollen," Report Michigan Hort. Society, 1884. p. 246.

10, 11, 12. Gray, Asa. "Naudin's Researches into the Specific Characters and the Varieties of the Genus Cucurbita," Journal of Sciences, 2d ser., vol. 24, p. 440; "Action of Foreign Pollen upon the Fruit," *ib.*, vol. 25, p. 122; "Hybridation in Mosses Affecting the Sporangium, etc., of the Female Parent," *ib.*, 3d ser., vol. 6, p. 390.

13, 14. Gentry, T. G., "The Fertilization of Certain Flowers through Insect Agency," Am. Naturalist, vol. 9, p. 263; review of same by Thomas Meehan, *ib.*, p. 274.

15. Halsted, B. D., "Cross-fertilization of Fruits," Bull. Iowa Ag. College, Bot. Dept., 1886, p. 37.

16. Lazenby, W. R., "Influence of Cross-fertilization upon the Development of the Strawberry," Proc. Am. Association for the Advancement of Science, vol. 3; p. 499.

17, 18, 19, 20, 21, 22. Meehan, Thomas, "On the Immediate Action of Pollen on Fruit," Rural New Yorker, 1885, June 13 and 20; "Immediate Influence of Pollen on Fruit," Proc. Acad. Nat. Sc. Phila., 1884, p. 297; Gardener's Monthly, 1885, pp. 86, 116, 150, 341.

23, 24. New York Experiment Station Report, "Influence of Different Pollens upon the Character of the Strawberry," 1885, p. 255; "Influence of Foreign Pollen upon the Character of Fruit," 1886, p. 179.

25. Skeels, F. E., "Cross-fertilization of Cucurbits," Ag. Science, vol. 1, p. 228.

SECONDARY RESULTS OF POLLINATION.

By E. W. Claypole, *Akron, Ohio.*

[The following paper was read before the Botanical Club of the American Association for the Advancement of Science at the New York meeting, August, 1881. It has not heretofore been published, and has been secured for this report mainly for its bearing on the topic of the preceding paper.]

The functions of the pollen and of the ovule, respectively, in the production of seed are so well established by observation that there is no occasion to say anything in explanation. The growth of the pollen tube and its elongation and penetration of the conductive tissue of the style may be seen in certain flowers by any tyro of the microscope. The passage of the fovilla, or fertilizing material, down the pollen tube to the micropyle, its entrance, and its union with the protoplastic material of the ovule, are fundamental truths in vegetable physiology, though our faith in most cases rests rather on testi-

mony than on observation. The subsequent changes that result from the union, the sudden stimulus given to cell multiplication, the rapid enlargement of the ovary, and the development and ripening of the ovules into seeds, are easily seen and are familiar to every one. However mysterious, this is the ordinary process of nature, and is in accord with the elementary principles of botany.

But in some cases things do not happen in this ordinary way, or just as our text-books say they should happen, and then there comes in a little difficulty in explaining how the results are accomplished.

Seeing, as we constantly do, the close connection between the fertilization of the ovule and the growth and maturation of the fruit, we are naturally led to the almost unconscious belief that one of these events is the consequence of the other, that the growth of the fruit is a consequence of the growth of the seed. And when we observe the countless cases in which the failure of the ovule is followed by the fall of the young fruit the unconscious belief becomes almost irresistible. A shower of rain washes away the pollen and our apple crop fails in consequence. The young fruit does not swell, but shrinks and falls. This happens so often and in so many plants that we cease to expect fruit where there is no seed.

Yet there are some facts that at least tend to show that the connection between the seed and the fruit is less close than we sometimes assume. Some of these also lead us to believe that the fertilizing influence of the pollen is not confined to the ovule.

As the first example of these secondary results, I will mention the obvious, but seldom noted, fact that the ovary can be developed and matured without the presence of the seed. This apparently proves that the swelling of the ovary is independent of the development and ripening of the ovule. It may be due to the direct action of the pollen on the ovarian tissue, but even this does not seem in all cases to be necessary.

As an illustration of this statement I will quote the Banana, which, as is well known, never bears any seeds at all. The fruit is solely the swollen and matured ovary, in which numerous abortive ovules may usually be seen.

The St. Michael's orange is another case in point. Though small, this variety is accounted the best of the many kinds cultivated in Europe, as it seldom contains a single pip. It has apparently been introduced into this country, as I have recently seen some oranges that were said to have come from Florida which, by the absence of seeds, formed a pleasant contrast to the usual seediness of the Florida fruit. (This variety is now grown in Florida and California.)

Again, our common Persimmon is sometimes entirely seedless. Once in Pennsylvania I met with a whole grove of these trees in which a seed-bearing fruit was the exception. The garden Radish also will often develop its pods without any seed. Any one, too, who will take the trouble to examine the fruits of the common Maple will soon learn that a large proportion of them contain no seed, but are simply hollow shells.

The well-known Sultana raisins sold in our stores owe the esteem in which they are held to the total absence of seeds, and the high-bred European Malaga grape is found almost as often without seeds as with them.

Less noticeable, but equally true and apposite, are the numerous instances, familiar to every careful observer, of cherries, plums, and peaches whose stones contain no kernels. All these facts abundantly

prove that the development of the embryo into a seed is not absolutely necessary, at least in these plants, for the full growth of the ovary into a fruit.

We may go yet further. The above-noted cases may be explained by the action of the pollen, not on the ovule, but on the tissue of the ovary itself. It may be said that the stimulation of cell growth, which is usually supposed to start with the ovule, was in all cases felt directly by the ovary. Be this as it may, we are compelled by these facts to admit that the effects of pollination are not limited to the ovule, but extend also to the ovary, even when the ovule is absent or abortive.

But the case of the apple and the pear shows a difference. Here, though the pips usually develop, the effect of the pollen extends beyond them. As before, it affects the ovary, but does not stop there. The calyx is involved, and, according to the views of some, the flower-stalks also. The effects of the pollen are therefore in this fruit felt by the ovule, the ovary, the calyx, and possibly by the flower-stalk.

What is true of the apple is also true of the pear, the quince, the medlar, the hawthorne, and many other plants of the Rose family. Their fruit is constructed on the same pattern, and the action of the pollen in all such cases must therefore be equally extensive.

But we may go even beyond this. We have all seen apples that contained no pips and yet were fully grown and showed all the characters of the variety. In these cases, as in those of the seedless orange, the banana, etc., the fertilizing effect of the pollen must have been directly exerted on the ovary without the intervention of the ovule.

A similar case is presented by a mulberry tree belonging to a friend of the writer. It is of the pistillate kind and is annually laden with fine fruit, though no staminate tree grows in the neighborhood and no staminate flowers can be found on the tree itself. Examination of the fruit also shows that the seeming seeds are merely shells without embryos. To assume that no pollen was concerned in the production of this fruit would be going too far, but it does seem the influence of the pollen, if present, must have been exerted directly on the ovary without the assistance of the ovule.

Further still, we now and then find an apple or a pear which contains no pip, but also no core, so that the very ovary itself is lacking. Yet such apples often grow to the usual size and if not always well flavored are nevertheless true fruits. This is usually the case when the tree has flowered out of season. A horticultural friend of mine has informed me that in the year 1832, when he was a boy, a late frost killed the apples, and that in the fall out of a peck or so of wretched fruit, which was all that the orchard produced, not a single one had a pip or a core.

The following extract from a letter published in Nature on November 4, 1886, bears on the same point. In it Dr. Maxwell Masters, the editor of the Gardener's Chronicle, says:

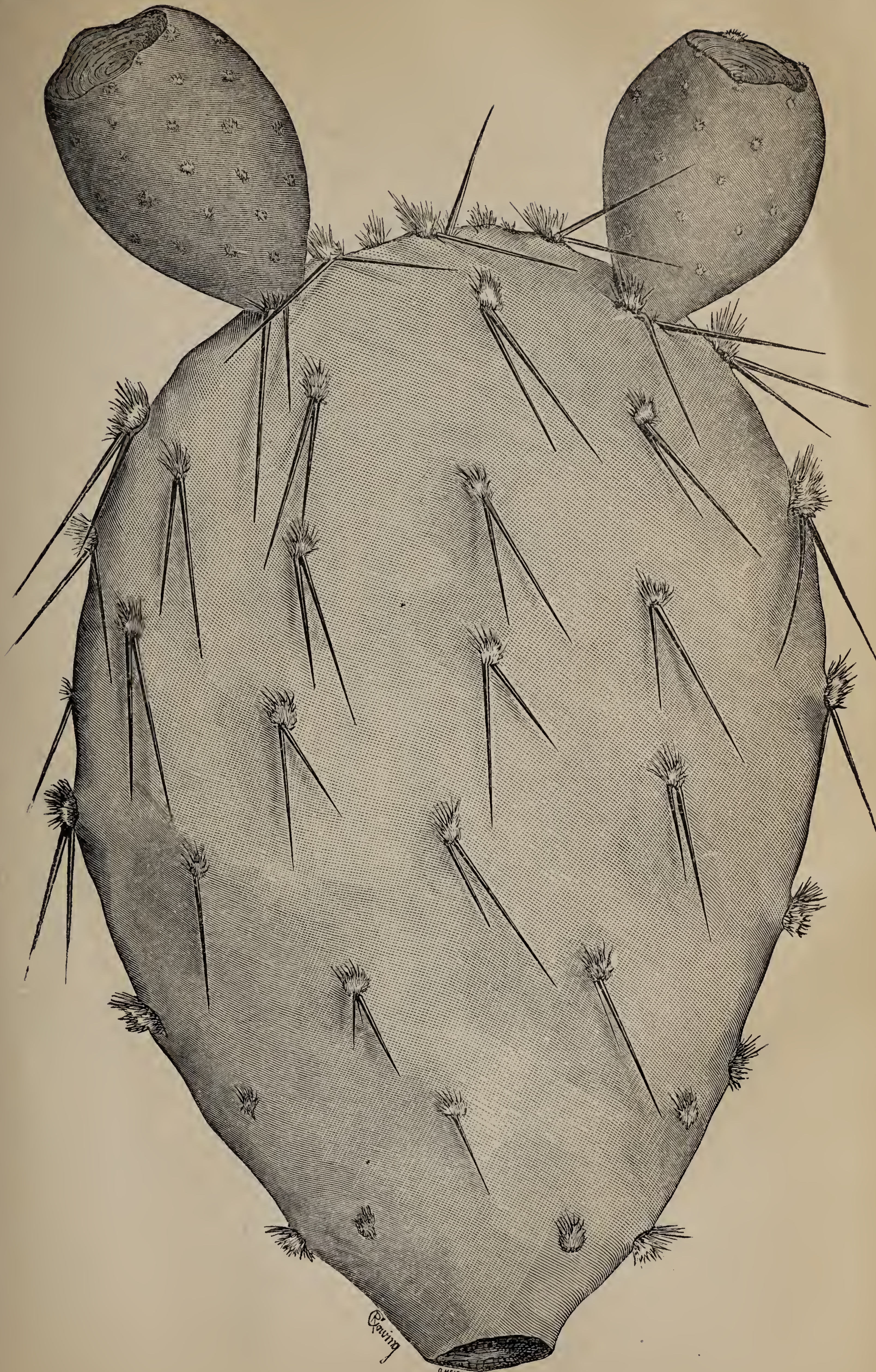
> The second crop of blossoms in pear trees is usually produced on shoots of the same year and they are often imperfect. The Napoleon produces some every year. Every year, too, I receive from the Trinity Botanical Garden, at Dublin, Bishop's Thumb pears on the summer shoots. They are more like fingers than "thumbs" and have no core. The fruit is eatable, but the carpels are absent.

We have here, apparently, a case of the direct action of the pollen on the calyx of the flower, perhaps through the medium of a rudimentary stigma and ovary, which were afterwards atrophied.

EUCHLÆNA LUXURIANS (TEOSINTE).

1. Male flowers. 2. Female flowers inclosed in sheath. 3. Seeds

EUROTIA LANATA (WHITE SAGE).

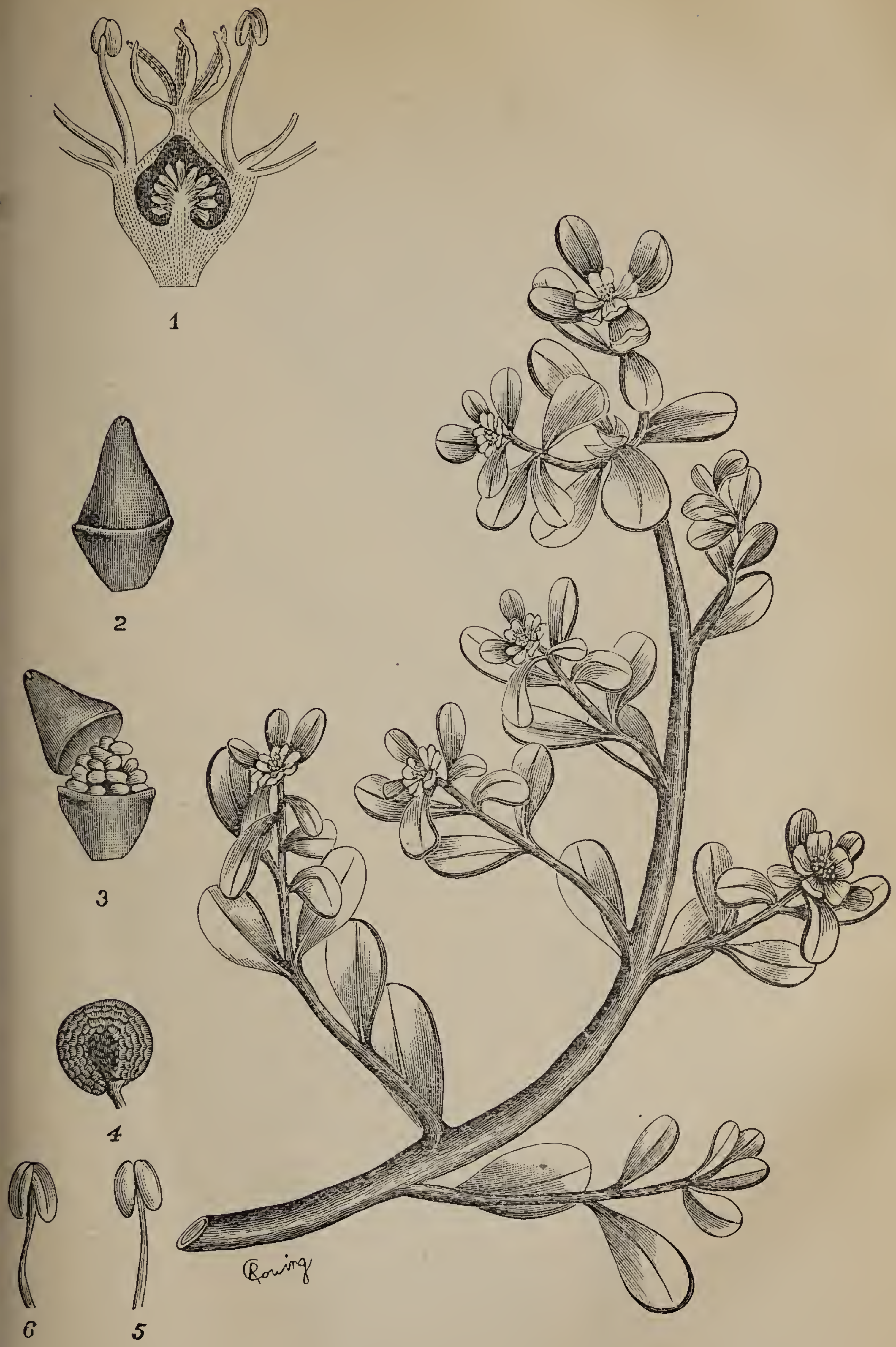


OPUNTIA ENGELMANNI.

ONOBRYCHIS SATIVA (SAINFOIN, ESPARSET).
1, 2, 3, 4. Parts of the flower. 5. The pod. 6, 7. The seed.

TRIFOLIUM HYBRIDUM (ALSIKE CLOVER).

PLATE VI.



PORTULACA OLERACEA (PURSLANE).

1. Longitudinal section of flower. 2 to 6. Ovary, seed, etc., magnified

Asclepias cornuti (Milkweed).

RANUNCULUS SCELERATUS (CURSED CROWFOOT).

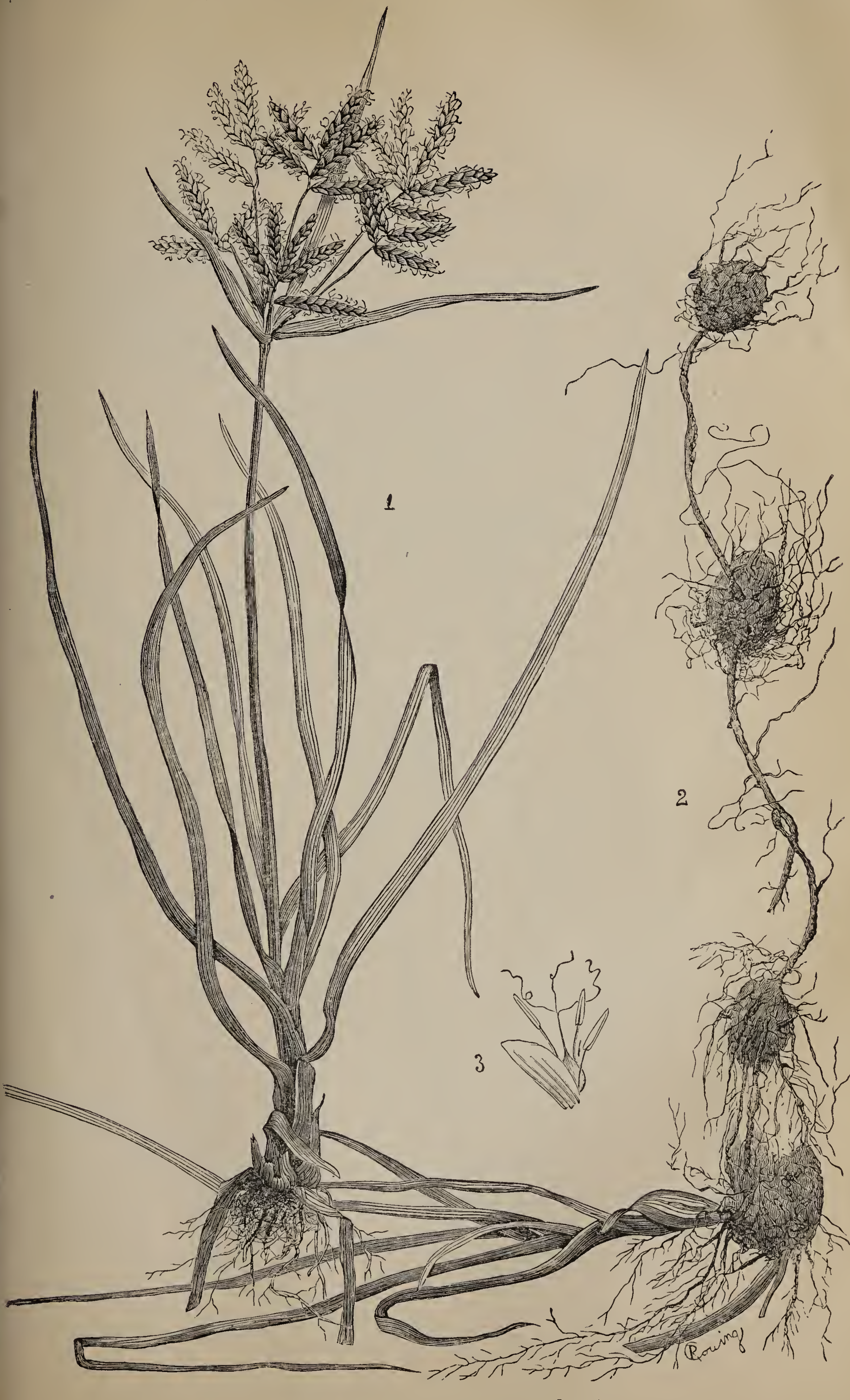
CHONDRILLA JUNCEA.
Root-leaves and top of the stem.

HYPERICUM PERFORATUM (ST. JOHN'S WORT).

AMARANTUS HYBRIDUS (PIG-WEED).

2. Male flower. 3. Female flower. 4, 5. Ovary and seed, magnified.

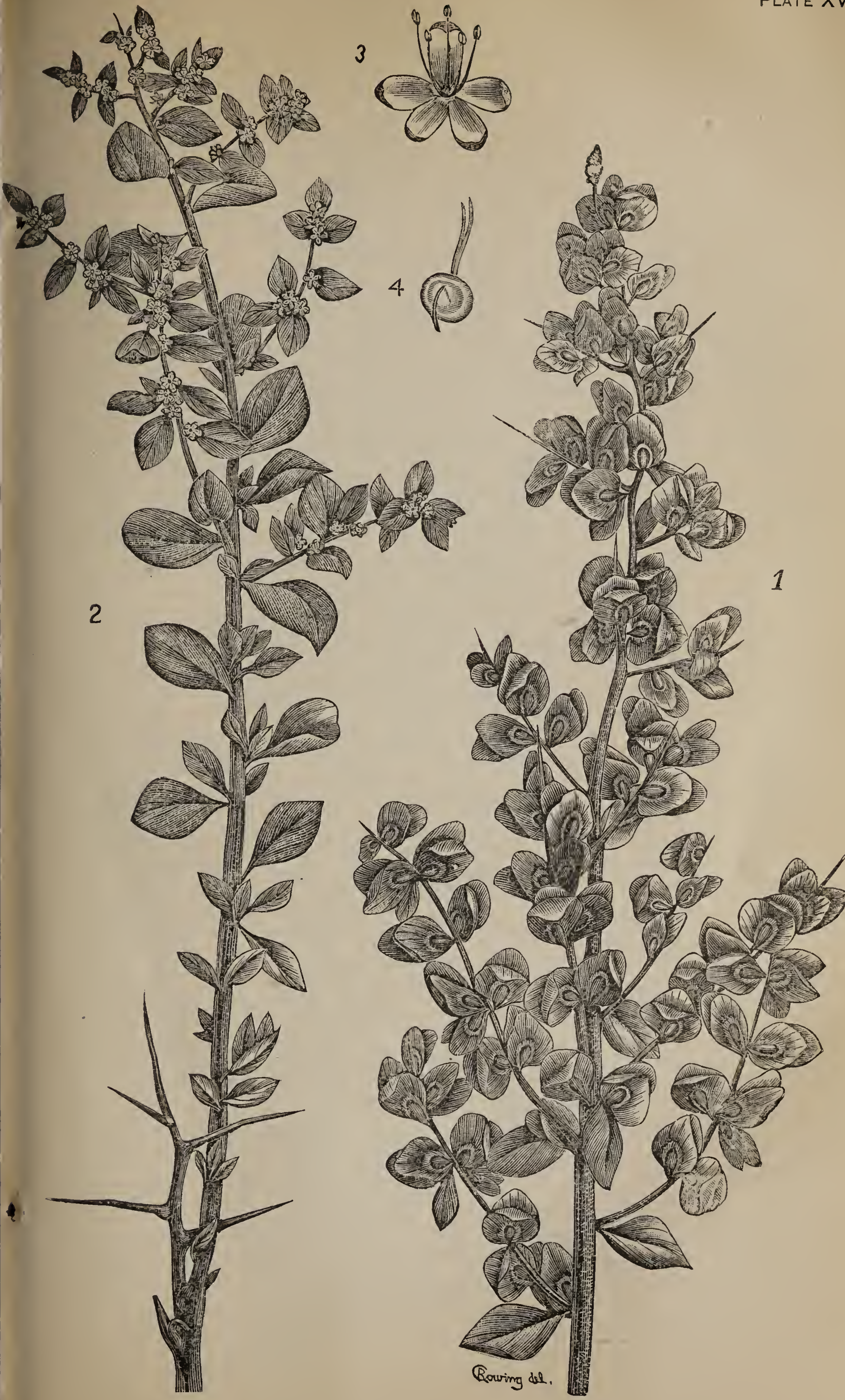
DAUCUS CAROTA (WILD CARROT).



CYPERUS ROTUNDUS (NUT-GRASS, COCO).
2. A string of tubers. 3. A flower, magnified.

TRIFOLIUM INCARNATUM.

BERBERIS VULGARIS (BARBERRY).



ATRIPLEX CONFERTIFOLIA (WHITE SAGE).

1. Female plant. 2. Male plant. 3. Male flower. 4. Ovary and styles.

ARTEMISIA FRIGIDA (SILVERY WORMWOOD)

In not a few fruits, so-called, the action of the pollen goes, seemingly, farther still. In the Strawberry is involved the receptacle, and the same is true to a less degree of the Blackberry and the Raspberry. The calyx grows with the growth of the seed in the Hazelnut, the Chestnut, the Hickories, and the Walnuts ; also, in the little Partridge-berry, the Blue-berry, and the Huckleberry. The head of the flowering stem swells and sweetens and becomes the chief part of the Fig, and the bracts that inclose the flower and seeds compose the so-called fruit of the Pine-apple.

Where, then, shall we limit the action of the fertilizing element of the pollen ? I am inclined to believe that it really has no limit, but that it is capable of extending through the whole plant.

Two facts in support of this opinion must here suffice. Most gardeners know that Pansies can not be well kept true to color when grown together in a bed for years in succession. Not only the seedlings, as might be expected, but the parent roots are apparently influenced by receiving each other's pollen and their colors thereby changed. The same is true of some other garden flowers. A friend of mine, who is largely engaged in growing the Gladiolus, has told me that for years he grew the "Shakespeare," a white variety, by itself, and year after year it remained true to color. But when for some reason he planted it one year near red varieties, the next year the same bulbs threw up stems that produced flowers that were partially red. Nor while they grew together could he again obtain perfectly white flowers.

These and other examples that might have been mentioned strongly indicate change in the parent plant, more extensive than those involved in the mere production of seed, or even of seed and fruit. They suggest a constitutional modification of varying and sometimes of wide range, involving other organs than those directly concerned in fructification, and enduring for years after the immediate cause has ceased to act. It seems far from improbable that a single act of fertilization may, in some cases, so change the nature of the parent plant that it may not again, throughout its whole life, be what it had previously been. Some of the occult variations that occur among plants may have their cause in the potent influence of pollen on the constitution of the parent.

The other kingdom of animated nature supplies facts that lend strong support to the view above stated. Without going into detail, it will suffice to say that the influence of the male animal is often permanent, and that young, subsequently produced, will show traces of it.

The influence of a quagga on a mare has been known to reveal itself years afterward by the production of a colt showing in several places the stripes of his stepfather. Darwin has collected several such cases, and many more might, without doubt, be brought together by a little investigation among men engaged in the breeding of animals. The subject, however, especially with regard to plants, has not received the attention which its importance deserves.

REPORT OF THE SECTION OF VEGETABLE PATHOLOGY.

SIR: I have the honor to present herewith my first annual report as chief of the Section of Vegetable Pathology, being the second report of the section of the Botanical Division devoted to the investigation of the fungus diseases of plants.

The constantly increasing correspondence has occupied much time and has been an important means of diffusing knowledge relative to plant diseases and the relations of our fungus pests to agriculture.

The collections of material illustrating the families of fungi have been considerably increased during the year and the specimens have been properly arranged for ready reference. There are now in the collection 5,572 sheets, standard herbarium size, on which are mounted 9,300 labeled specimens, in 3,000 pockets of uniform size, $6\frac{1}{2}$ by $3\frac{3}{4}$ inches; there are an equal number of specimens, largely duplicates of those mounted, arranged in order by host, constituting what we term the economic collection.

Permanent mounts of microscopical preparations, to the number of about 500, have been made of material under investigation during the year. The series of slides illustrating the downy mildew, the grape-rot producing fungi, and the smuts and rusts of grains and grasses are particularly full. Thanks are due to Mr. W. W. Calkins for a large and well-prepared collection of Florida fungi, and to Prof. S. M. Tracy for a particularly interesting collection of Western species. A collection of European fungi of the vine has been presented by Prof. P. Viala. This is particularly valuable as illustrating the species described in Professor Viala's work, "Les Maladies de la Vigne."

Many valuable specimens have been acquired through correspondents who have submitted them for examination, affording valuable material for future investigations.

I.—NOTES ON THE DISEASES OF THE VINE.

The study of the fungus diseases of the vine has been continued, particular attention being given to the subject of the treatment of mildew and black-rot. A detailed account of the work of the Section in this direction has been published in a special bulletin.

Throughout the Atlantic and Southern States the season of growth was generally wet and the weather such as to promote the development of fungi. From western New York through Ohio, Indiana, Michigan, Wisconsin, Illinois, and Missouri a long-continued drought prevailed, preventing the development of destructive plant parasites, and from this section there have been very few complaints of the ravages of fungi.

The downy mildew, black-rot, and anthracnose were especially prevalent, the two first named causing serious injury to the vines or great losses in the crops in New Jersey, Maryland, Virginia, North Carolina, and in the States south and west from the latter point. In California the ravages occasioned by oïdium and downy mildew have been slight, and it has been discovered that the latter disease is at present limited to a few restricted areas in that State. There is no evidence that the black-rot, so destructive in Eastern vineyards, has yet appeared on the Pacific slope.

Pourridie or grape root-rot has been discovered at several points—Missouri, Texas, and California—and its range will doubtless be extended by further observation.

As a result of field investigations two new forms of grape-rot have been discovered—bitter-rot and white-rot. The former is the most widely distributed, having been observed in the States in the East and as far west as Texas. The latter has been seen only in the extreme southwestern part of Missouri and adjacent parts of Indian Territory.

*A.—Bitter-rot of grapes.**

Although this disease appears to have been known to our viticulturists for several years, its cause was only recently determined. In company with Professor Viala, of the National School of Agriculture of Montpellier, France, I observed the disease for the first time in the vineyard of Hon. Wharton J. Green, at Fayetteville, N. C. From the studies there made, and from subsequent laboratory investigations, the characters of the parasite causing the malady were determined and were made the subject of a communication to the French Academy of Sciences.

It appears that the fungus is both saprophytic and parasitic in its habits and occasions very considerable destruction of the fruit, especially of certain white varieties, the Martha for example.

That which especially characterizes this disease in distinction from the black-rot is that it begins its ravages at the time when the berries commence to ripen, and continues until their perfect maturity. Excessive humidity is even more essential to its development than to that of the Physalospora. The importance of this malady is evident, for, under favoring conditions, it may destroy the fruit that has escaped the ravages of black-rot. The fungus attacks the shoots, the common peduncle of the bunches and its ramifications, but it is upon the berries that its action is most conspicuous. A rosy discoloration, brighter on varieties with white fruits than on dark colored sorts, is the first manifestation of the disease. This discoloration extends rapidly by concentric zones until the whole berry is involved, the berries, however, retaining their original contour, or only appearing to be slightly wilted, and becoming even more juicy than is normal. Soon numerous small, slightly elevated points appear over the surface, and in two or three days these little elevations, which are the points where the fungus is maturing its fruit, have completed their development. The berry then becomes shriveled, as in the case of black-rot, but in a different fashion. The berry remains clear brown or deep purple in color, never becoming so black as in black-rot, and

* Accounts of this disease have been published in Comptes Rendus, Sept, 12, 1887; Agricultural Science, vol. I, p. 210; Colman's Rural World, Oct. 13, 1887; Proceedings New Jersey Horticultural Society for 1887, p. 114.

the pustules which stud the surface are less numerous and less convex. In advanced stages the berries lose their hold upon the pedicels and fall to the ground at the slightest jar. Those destroyed by black-rot usually remain strongly adherent and generally fall with their pedicels attached.

FIG. 1. Illustrates a highly magnified vertical section through one of the fruiting pustules of the fungus of Bitter-rot. A compact growth of spore-bearing hyphæ has burst through the epidermis, *c, c*. Below is the browned and dead tissue of the berry, *d, d*, growing through which are the mycelial threads of the fungus.

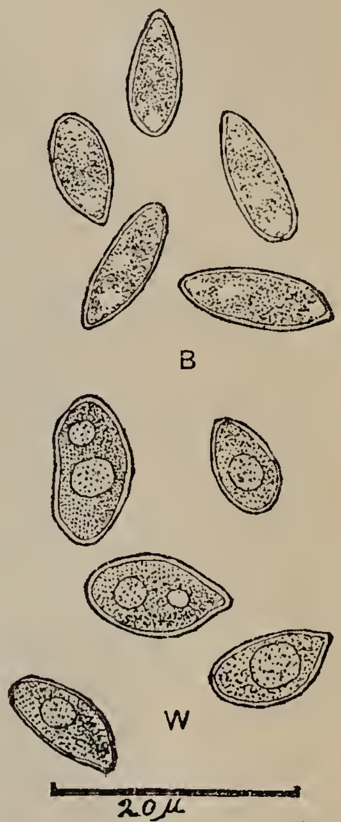


FIG. 2. Spores of Bitter-rot, B, and White-rot, W.

The mycelium of the fungus of bitter-rot penetrates the tissues of the berries, even entering the seeds, for upon the latter it is not uncommon to find the fruit of the parasite.

The spores produced are very minute, ovoid or navicular-form, and have rather thick walls. They germinate quickly when sown in aerated juice of grapes diluted with water.

Bitter-rot is most to be feared when frequent rains occur during the ripening period, but, like other fungus diseases of this class, it is sure to be most severe in poorly drained soils and on vines previously weakened by mildew.

B.—White-rot.

This disease appears to be of American origin, although the fungus causing it was first recognized in Italy, in 1878. In 1886 it was discovered in France, and during the past season (1887) has become widely spread in the latter country, occasioning no little alarm. Frequent accounts of it have been published in French and Italian journals, the most complete and best illustrated being that given by Dr. F. Cavara.*

Since its discovery in this country, in September of the present year, it has been described by the writer in Colman's Rural World, October 27, 1887; and in the proceedings of the New Jersey Horticultural Society for 1887, p. 139.

* Intorno al Disseccamento dei Grappoli della Vite. Instituto Botanico della R. Universita di Pavia, 1888, p. 11, Pl. IV[a].

The mycelium of the fungus (*Coniothyrium diplodiella*) is found to be abundant in the pulp of the berries attacked, and it sometimes fruits upon the surface of the seeds. Generally, the fungus first attacks the common peduncle or branches of the cluster and, by interrupting the circulation of the nourishing fluids, causes the berries to wither and dry up. In such cases the berries may or may not be directly attacked. Infection of the peduncle or pedicels with germinating spores is easily effected, but attempts to infect the berries have so far failed.

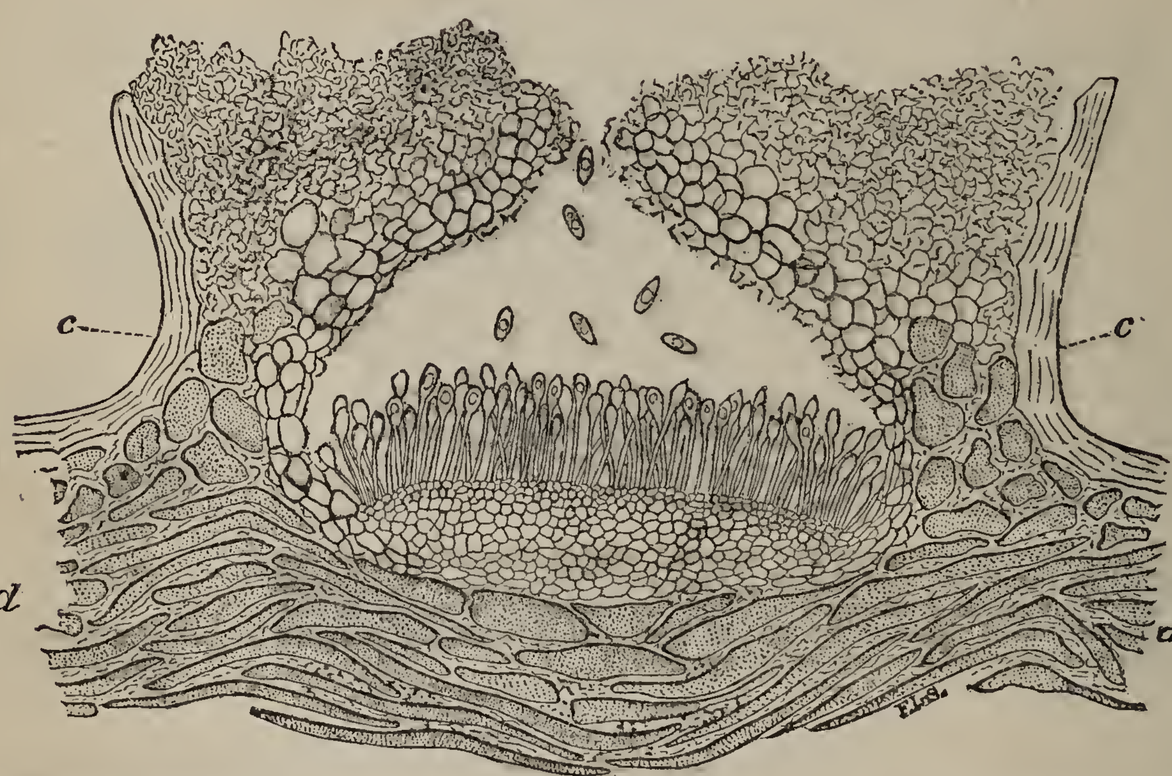


FIG. 3. A vertical section through one of the fruiting pustules—pycnidia—of the fungus of White-rot. *c c*, cuticle of the berry that has been broken through by the development of the fungus. *d d*, browned and dry tissue of the berry. The simple spores are borne on slender stalks arising from a layer of very delicate tissue at the bottom of the pycnidium.

Like the black-rot fungus, this produces minute pycnidia or spore conceptacles, which appear at the moment when the berries commence to ripen. These lie just beneath the cuticle, through which they finally burst, first appearing as shining, rosy points, then white, and finally brown. When fully developed, the pycnidia are surrounded by a thin membrane of a rather dark brown color. The ovoid spores are borne upon slender stalks or basidia, either simple or branched, which spring from a layer of very delicate tissue occupying the lower part of the pycnidium. They are at first colorless, but eventually assume a brown tint. At a temperature of 65° they germinate readily in water, pushing out germ-tubes from any part of their surface.

No remedy is known for white-rot, but it has been observed here, and very generally in France, that where the vineyards have been treated with eau celeste or the Bordeaux mixture the disease was far less prevalent than in similarly located vineyards not treated.

C.—Grape-leaf spot disease and black-rot.

In Bulletin 2 of the Botanical Division, page 40, Grape-leaf spot disease was treated as distinct from black-rot, for the writer at that

time was not convinced of their identity, although the close similarity of the pycnidial spores of *Phyllosticta labruscæ* with those of *Phoma uvicola* was, of course, observed.

Special attention has been directed to this subject during the past summer, and, as the result of extended field observations, I have been forced to conclude that the grape-leaf spot fungus and the fungus of black-rot of grapes is one and the same. In France the *Phyllosticta labruscæ* has been observed only in those vineyards affected with black-rot, and the same holds true for the United States. Wherever the *Phyllosticta* occurs it is in regions where black-rot prevails. In California, where the latter disease has not yet appeared, no signs of the fungus upon the leaves of the vines was discovered.

The brown spots upon the leaves figured and described in my report on the Fungus Diseases of the Vine* must, then, be regarded as simply the manifestation of the black-rot on the foliage.

The fact of the identity of the leaf form with that occurring upon the berries is especially important in connection with the question of treatment, for black-rot, like the downy mildew, must be treated preventively. As a rule, the black-rot fungus first attacks the leaves some days and often a week or two before the berries are affected. It may sometimes be observed on the foliage even before the vines have bloomed.

By watching the foliage the vineyardist may be warned of the presence of this dreaded parasite in good season, and upon the first signs of its manifestations upon the leaves he ought to begin the application of remedies or preventives in order to protect the fruit. Evidence is accumulating that the sulphate of copper compounds possess some value in checking this disease. We have been assured by some experimenters that there was a very decided improvement in respect to black-rot in vineyards treated with these preparations compared with those not treated. In France, also, similar results have been reported. M. Prillieux, in a communication addressed to the French minister of agriculture, says:

> It seems that treatments with the salts of copper will very economically replace the difficult and costly method of collecting and destroying the leaves affected by black-rot. M. Frechou has been assured by his laboratory experiments, carried on at Nerac, the results of which will finally be made public, that the slightest trace of sulphate of copper is sufficient to render impossible the germination of the spores of *Phoma uvicola* as well as those of *Peronospora*, and on the other side, the slight injury caused by black-rot in the valley of Herault upon vines treated by eau celeste or Bordeaux mixture for the downy mildew ought to afford some hopes of success in preventing the appearance of black-rot upon the berries and its disastrous consequences, by destroying it at its first appearance upon the leaves by means of the same remedies, the efficacy of which is recognized for combating the downy mildew. It is possible therefore, without increase of labor, to protect the vines from both diseases by the same treatment.

The hopes that by a proper use of sulphate of copper compounds we may find a successful treatment for black-rot certainly justify further careful experiments in their use.

---

*Bull. 2, Bot. Division, p. 40, Plate VII, figs. *c*, *d*, *e*.

II.—NOTES UPON THE TREATMENT OF VINE DISEASES.

The preparations considered most likely to prove valuable as remedies in the treatment of mildew and black-rot were published last spring (1887) in the following circular form:

[Section of Vegetable Pathology.—Circular No. 3.]

Treatment of the downy mildew and black-rot of the grape.

To the vineyardists of the country:

Last year a circular was sent out by this Department recommending for trial certain remedies for the mildew and rot of the grape.

The results of experiments in 1886 have fully demonstrated the value of sulphate of copper ("blue-stone") over all other remedies in combating the mildew, and the results of many chemical analyses of the fruit and parts of vines treated with the copper compounds have clearly shown that there is no danger to health attending their application. The only precaution advised is not to apply them near (within fifteen days of) the vintage.

In their employment the fact must be kept in mind that their action is only preventive, therefore their application should be made early in the season, from the latter part of May to the end of June. Subsequent applications act only in so far as they serve to check the spread of the disease. The amount of the fluid compounds required to treat an acre of vines will depend largely upon the kind of pump and spraying nozzle used to apply them, and upon the extent of growth of the vines themselves; the amount may vary from 20 to 35 gallons.

The following are the formulæ of the remedies which so far have given the best results. An account of the results of trials you may make with one or more of them is earnestly desired, and a blank form for making up a report for the use of the Department in future publications will be sent you upon the receipt of the addressed postal card inclosed herewith.

LIQUID REMEDIES.

(1) *Simple solution of sulphate of copper.*—Dissolve 1 pound of pure sulphate of copper in 25 gallons of water. Spray the vines with a convenient force-pump having a nozzle of fine aperture. Less lasting in its effect than the next, as it is easily washed off by rains.

(2) *Eau celeste, blue water* (the "Audoynaud process").—Dissolve 1 pound of sulphate of copper in 3 or 4 gallons of warm water; when completely dissolved and the water has cooled, add 1 pint of commercial ammonia; then dilute to 22 gallons. The concentrated liquid should be kept in a keg or some wooden vessel and diluted when required for use. Apply the same as in the case of simple solutions.

The effects obtained by this preparation have been equal to those resulting from the use of the copper mixture of Gironde, and are said to be even more lasting.

(3) *Copper mixture of Gironde, Bordeaux mixture.*—Dissolve 16 pounds of sulphate of copper in 22 gallons of water; in another vessel slake 30 pounds of lime in 6 gallons of water. When the latter mixture has cooled, it is slowly poured into the copper solution, care being taken to mix the fluids thoroughly by constant stirring. It is well to have this compound prepared some days before it is required for use. It should be well stirred before applying. Some have reduced the ingredients to 2 pounds of sulphate of copper and 2 pounds of lime to 22 gallons of water, and have obtained good results.

Well made pumps with specially constructed nozzles are required for the application of this compound, unless we resort to the tedious and wasteful method of using brooms or wisps made of slender twigs, which are dipped into the compound and then switched right and left so as to spray the foliage, as directed in our circular of last season. The Vermorel apparatus, including reservoir, pump, and spraying nozzle, is well adapted for vineyard use, and is specially constructed for applying the various liquid preparations containing sulphate of copper.

POWDERS.

(4) *David's powder.*—Dissolve 4 pounds of sulphate of copper in the least possible amount of hot water, and slake 16 pounds of lime with the smallest quantity of water required. When the copper solution and the slaked lime are completely cooled, mix them together thoroughly; let the compound dry in the sun; crush and

sift. Apply with a sulphuring bellows furnished with an outside receptacle for the powder. The copper coming in contact with the leather will soon destroy it.

(5) *Sulphatine.*—Mix 2½ pounds of anhydrous sulphate of copper with 15 pounds of triturated sulphur and 10 pounds of air-slaked lime. Apply in the same manner as No. 4.

Both these powders (Nos. 4 and 5) ought to be procured from the manufacturer, prepared ready for use.

[NOTE.—It is very probable that Nos. 2, 3, 4, and 5 will be found equally serviceable in preventing potato "blight" and "rot." No. 5 should be employed when one has to contend with both the downy and powdery mildews. For apple scab we suggest trials with Nos. 2 and 3.]

The degree of success attending the use of these compounds will depend more or less (1) upon their careful preparation, (2) the time of the application, (3) the more or less intelligent manner in which they are applied, (4) the atmospheric conditions existing at the time or which may follow the applications, (5) the number of treatments made, and (6) the purity of the copper used.

In all cases where these remedies are tried a number of plants or vines should be left untreated to serve as "control experiments," for comparison with those treated.

Prices of materials (subject, of course, to variations):*

Sulphate of copper, pure:		
In quantity, by the barrel	per pound..	$0.05 to $0.06
At retail	do....	.10
Anhydrous sulphate of copper	do....	.28
Flowers of sulphur:		
Wholesale	do....	.02½
Retail	do....	.05 to .06
Ammonia:		
Wholesale	do....	.05 to .06
Retail	do....	.10
Lime	per barrel (200 lbs.)..	1.05
Sulphatine, in quantity	per pound..	.05 to .06

NORMAN J. COLMAN,
Commissioner of Agriculture.

WASHINGTON, D. C., *April*, 1887.

The request that those trying any of the proposed remedies should report to the Department the character of the experiments made and the results obtained, met with generous response, nearly 200 reports being received. The substance of these reports will appear in the bulletin above referred to. A considerable diversity exists in the results obtained, which, for the most part, may be accounted for by the diversity in the manner of making the applications and especially by the varying climatic conditions in the different regions where the trials were made. In the hands of many the simple solution, eau celeste and the Bordeaux mixture gave excellent results for mildew, and quite a number claimed that one or the other of these preparations served to check the black-rot.

In almost all cases where these remedies were tried one or both of the diseases (black-rot and downy mildew) had already appeared at the time of the first applications. Understanding as we now do, the habits of the fungi causing these maladies, we know that our only hope is in the employment of *preventive* measures. If the sulphate of copper compounds are employed they must be used in season to

* Philadelphia quotations February, 1888: Flowers of sulphur, in barrels, 3 cents per pound; retail, 4 cents per pound. Powdered sulphur, in barrels, 3 cents per pound; retail, 4 cents per pound. Liver of sulphur, wholesale, 18½ cents per pound; retail, 25 cents per pound. Carbonate of soda, by the cask, 2 cents per pound; retail, 4 cents per pound. Carbonate of copper, 62½ cents per pound. Sulphate of copper, pure in crystals, 7 cents per pound. Sulphate of copper, anhydrous, 45 cents per pound. Liquid ammonia, in carboys, 7½ cents per pound; retail, 25 cents per pound. David's powder, per barrel (200 pounds), $12.50; 10 cents per pound. Sulphatine, per barrel (200 pounds), $16; 20 cents per pound.

act as preventives. We must cover the foliage and other parts of the vine subject to attack with a preparation which, upon drying, will adhere for a considerable time and prevent the germination of the fungus spores which may fall upon these parts. It is probable, also, that the nature of the cuticle may be so modified by the preparations used as to prevent the penetration of the germ tubes to the tissues within. In either case we must forestall the attacks by early applications, and to protect the later growths of shoots and foliage the applications must be several times repeated. In an ordinary season three applications will insure freedom from the mildew, but if the season prove a wet one a larger number may be necessary.

The methods and manner of making the applications are important considerations. A good apparatus for applying the liquids and powders is half the battle. When one has a vineyard of considerable size it is necessary to have spraying pumps or bellows which can be operated easily and quickly. The best form of sprayer for vineyard use is the portable arrangement designed for carrying on the back, knapsack fashion, having the reservoir and force-pump combined. Such an apparatus has recently been designed by Mr. Adam Weaber, of New Jersey. In form this resembles the Vigoroux sprayer, or the "l'Eclare" of Vermorel, of French manufacture, but the pump is constructed on different principles. With the better appliances of this class one man can easily spray from three to five acres of vines per day.

The spraying should be done thoroughly; that is, all the parts ought to be covered with the application, but care should be used not to *drench* the plants or vines. An excessive application is not only wasteful but liable to result in injury to the objects treated.

The amount of material used per acre will depend upon the season, extent of foliage growth, and the apparatus employed in applying it. In general, we would recommend for the liquids 25 gallons for the first, 35 for the second, and 45 for the third application.

The nozzle used should give a fine, mist like spray, or rather a cloud of vapor, which will envelop the plants, wetting them completely, but not so abundantly as to cause the liquids to drip from the leaves and shoots. Both the eddy chamber or cyclone nozzle, and Nixon's climax nozzle will yield a spray of the desired character. The latter is only suitable for clear liquids; when such compounds as the Bordeaux mixture are used, a nozzle with a degorger or device for clearing, like the Vermorel nozzle, is necessary. Improvements in our fungicidal appliances are greatly needed, and may be confidently looked for at no distant day.

As with liquids, so with powders, they should be distributed finely and evenly, their presence on the leaves, etc., after application being just perceptible. An excess of such powders as sulphatine (which is one of the best when properly applied) is very likely to injure the plants, particularly under a hot sunshine. Bellows furnished with outside receptacles for the powders are necessary, as the corrosive action of the powder will very soon destroy the leather if placed in contact.

As to the amount of powder to be used per acre, we would say for the first treatment 35 pounds, 45 or 50 pounds for the second, and 60 pounds for the third.

In respect to the remedies enumerated in the above circular, the use of the simple solution has in many instances resulted in injury to the foliage. As it is not advisable to reduce the percentage of sul-

phate of copper in the solution by the addition of more water, the simple solutions had best be discarded in treatments during the growing season.

Eau celeste also has, in the hands of some, injured the foliage materially, and a modification of the original formula is suggested in order to overcome this danger. In 2 gallons of hot water dissolve 1 pound sulphate of copper, in another vessel dissolve 2 pounds of ordinary carbonate of soda; mix the two solutions, and when all reaction has ceased add 1½ pints of liquid ammonia; when desired for use, dilute to 22 gallons.*

It is stated† that all danger of injury to the foliage from the first applications, made while the shoots are yet young and tender, may be entirely overcome by preparing the eau celeste for the first treatment in the following manner: Dissolve 1 pound sulphate of copper in a gallon of hot water, to this solution add liquid ammonia, a little at a time, until all the copper is precipitated; the liquid is then turbid and blue in color. Add two or three gallons of water and let stand to settle. Then pour off the clear liquid which contains sulphate of ammonia—the compound which causes the burning of the leaves. Then pour upon the precipitate left in the vessel just enough liquid ammonia to dissolve it. The result is a clear liquid of a beautiful deep blue color. When required for use dilute to 22 gallons.

Eau celeste prepared in the ordinary manner may be used without fear after the vines are in full foliage.

Considerable latitude is allowed in quantity of lime and copper sulphate in the Bordeaux mixture, but the amount of the latter ought not to fall below 4 per cent. The most recently recommended formula for preparation of this compound is 4 pounds of sulphate of copper, 2 pounds lime, 25 gallons water.‡ This reduces very much the cost of material, and the labor in applying is far less than when prepared according to the original formula, but some have found it to be inefficient.

III.—Potato blight and rot.

The value of eau celeste and the Bordeaux mixture in treating potato blight and rot (caused by *Phytophthora infestans*) has been frequently stated in France, and the very great need of discovering effective means for checking these diseases in this country was the occasion for preparing the following circular, which the Commissioner ordered to be printed and distributed:

[Section of Vegetable Pathology.—Circular No. 4.]

Treatment of the potato and tomato for the blight and rot.

SIR: In Circular No. 3 of this section, addressed to the vineyardists of the country, it was suggested that some of the preparations therein described might be found useful in preventing potato "blight" and "rot," this suggestion being made upon the knowledge of the fact that the fungus which causes the mildew of the vine is very similar in character to that which produces the diseases named above. The published evidence of experiments made in France, in 1886, in the treatment of potatoes and tomatoes for "blight" and "rot" with the Bordeaux mixture, gives additional weight to this subject and renders it highly probable that by the application

* Formula of M. Masson, Progrès Agricole, July, 1887.
† "Progrès Agricole et Viticole," April 29, 1888.
‡ Viala and Ferrouillat, "Manuel pratique pour le Traitement des Maladies de la Vigne," 2d ed., Mar., 1888, p. 27.

of preparations containing sulphate of copper we will be able to prevent, or at least to greatly diminish, the ravages of one of the worst enemies of the American farmer.

Directions for the preparation and application of the remedies thought most likely to prove successful are here presented, and it is earnestly recommended that they be given a thorough trial in order to demonstrate their supposed value.

LIQUIDS.

(1) *Eau celeste, blue water,* (the "Audoynaud process").—Dissolve 1 pound of sulphate of copper in 3 or 4 gallons of warm water; when completely dissolved and the water has cooled, add 1½ pints of commercial liquid ammonia, then dilute to 22 gallons. The concentrated liquid should be kept in a keg or some wooden vessel and diluted when required for use. Apply in clear weather with a suitable force-pump having a fine spraying nozzle, which will spray the plants thoroughly but not drench them. Make the first application when the plants are in bloom, the second a week or ten days later, and if the weather be such as will favor the development of "rot," a third, and perhaps a fourth application should follow within about the same intervals.

(2) *Copper mixture of Gironde, Bordeaux mixture.*—Dissolve 4 pounds of sulphate of copper in 16 gallons of water; in another vessel slake 4 pounds of lime in 6 gallons of water. When the latter mixture has cooled, it is slowly poured into the copper solution, care being taken to mix the fluids thoroughly by constant stirring. It is well to have this compound prepared some days before it is required for use. (The sulphate of copper ought to be purchased in a powdered state, as it dissolves with difficulty in the ordinary crystalline form.)

This liquid, slightly thickened because of the lime, may be applied with small brooms or wisps made of slender twigs, which are dipped into the compound and then switched over the plants so as to thoroughly spray the leaves. This method is wasteful and tedious, however, and where one has a considerable area to cover it would be economy to procure a spraying pump; the essential features of a good machine are ease and rapidity of application with economy of material.

Follow the same general directions in making the applications as are given under No. 1.

POWDERS.

(3) *Sulphatine* (the Estève process).—Mix 2 pounds of anhydrous sulphate of copper with 20 pounds of flowers of sulphur and 10 pounds of air-slaked lime.

(4) *Blight powder.*—Mix 3 pounds of anhydrous sulphate of copper with 97 pounds of flowers of sulphur.

This amount will be sufficient for one application to 5 acres of potato plants.

Powders possess the advantage over the liquid remedies of requiring less labor in transportation and of being more easy of application, consequently they will be preferred to the liquids, should they prove equally efficacious.

For applying the powders, which ought to be done when there is no wind and when the leaves are wet with dew or rain, the primitive arrangement, made of tin and constructed like a large pepper-box, or rather like an inverted funnel with fine wire gauze fastened over the lower end, and which, when filled with the powder, is held over the plants and shaken, is efficient and at the same time simple and inexpensive. Only enough of the powders, especially of the sulphatine, should be applied to be simply visible upon the leaves, as heavy doses may burn them.

Owing to the continual motion of the leaves of potato and tomato plants, by which both surfaces are liable to receive the spores of the fungus, the applications ought to cover both sides; this can best be accomplished by the use of a bellows with an extension nozzle, enabling the operator to direct the blast.

The degree of success attending the use of these compounds will depend more or less (1) upon their careful preparation, (2) the time of application, (3) the more or less intelligent manner in which they are applied, (4) the atmospheric condition existing at the time or which may follow the applications, (5) the number of treatments made, and (6) the purity of the lime and sulphate of copper used.

The following observations are essentially the same as those recently published by the French minister of agriculture, in a circular of similar import to this.

The experiments should be conducted in such a manner that the vines or plants treated and those left untreated (to serve as control experiments) may be comparable; they ought to be of the same variety, cultivated at the same time, and in all respects alike. The digging of the treated and untreated plants ought to be made simultaneously, for it has been proven that the tubers may be infected at the moment when they are taken from the ground, and that the chances of infection are

much greater in the early morning when the air and ground are damp, than later in the day when there is less moisture.

At the moment of digging, count the rotton tubers found in the soil and also those which are spotted only. The weights of the crops from the treated plants and from those not treated should be determined, and they should be preserved separately during the winter, but under identical conditions, for the purpose of learning if there be any difference between them in respect to infection.

Much may be accomplished in the prevention of potato-rot by renewal of seed, selection of varieties, and especially by planting only in light and well drained soils; also, perhaps, by following certain systems of cultivation; but the evidences we have of the serious losses occasioned by this disease throughout the potato growing regions of the United States render it imperative on the part of the Government to exercise all possible efforts for its prevention, and I respectfully recommend the immediate distribution of this circular, urging those who suffer directly from the ravages of the diseases named to experiment with the remedies and report to you the results obtained.

Respectfully,

F. LAMSON SCRIBNER,
Chief of Section.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

We have received no reports on the use of these remedies, and do not know that they have yet been tried, but we feel confident, however, that the remedies here enumerated, when properly made and applied, will prove effectual in preventing the ravages of the potato blight and rot.

IV.—FIELD OBSERVATIONS AND EXPERIMENTS.

In order to gain an accurate knowledge of habits of parasitic fungi and the ravages they produce it is absolutely necessary to carry on field investigations. The Department ought not to be obliged to depend upon volunteer reports for a knowledge of facts acquired through private experiments. Such reports, especially when treating of matters relating to fungi, are very likely to be misleading, owing to the imperfect knowledge generally possessed regarding this subject. And as to the matter of fungicides and the treatment of plant diseases, valuable conclusions can only be reached through field work carried on by some one familiar with the nature and habits of the fungi to be combated.

If this work be continued in a manner at all commensurate with its importance, and results obtained that shall meet the approval and confidence of the people the Department is designed to serve, it is necessary that Congress provide for a station which shall be under the absolute control of the Department for the needed field experiments. Office work is necessary, laboratory work must be done, but to attain practical results, and it is the practical conclusions which the farmer and fruit-grower are after, it is imperative that we go outside of the office and laboratory, and continue our studies and experiments in the field upon living plants. A station containing not less than 10 acres of land, located where a large variety of grains, vegetables, vines, and fruit trees and shrubs could be cultivated, is essential to the successful prosecution of the work required from this Section, and the development of its full power for usefulness. Here the effects of the parasites upon the host can be studied, inoculations of healthy plants made, and experiments carried on in the treatment of plant diseases. A small green-house is an important adjunct to such a station, and the work would be further facilitated by having in the

same location the laboratory for the microscopical studies and finer cultures.

Such a station, it is confidently expected, will be established at no distant day, and the results which then may be accomplished will be more in accord with the dignity of the position which this Department is designed to hold in its relations to American agriculture.

V.—Special subjects.

The plant diseases discussed in the following pages of this report have been made the subject of investigation either by myself or my assistants. Very little claim is made to originality, excepting, perhaps, in the manner of presentation; but it is hoped that this, together with the accompanying illustrations, will be found valuable and meet with public approval.

The chapters on the "Smut of Indian Corn," "Corn Rust," and the "Powdery mildew of the Gooseberry" were prepared by outside agents, employed for the purpose because of their having devoted particular attention to these subjects.

I wish here to express my thanks to my assistants for their constant diligence and ever-ready willingness to perform the duties assigned them, and especially to commend the valuable services rendered in the preparation of the following pages by the assistant, Mr. B. T. Galloway, and by Miss Effie A. Southworth.

1.—Strawberry-leaf blight.

Sphærella fragariæ, Sacc.

(Plate I.)

(*a*) general observations.

There are a dozen or more fungi which infest the Strawberry plant, but the best known, and doubtless the one more injurious than all the others combined, is that which causes the disease we have here named Strawberry-leaf Blight. It has been called the "spot disease of strawberry leaves,"* "sun-burn," and often "strawberry rust."†

This disease is due to the attacks of a parasitic fungus which is common both in this country and in Europe. Here we have observed it from Maine in the East to California in the West, and complaints of its ravages have come to us from Florida and other sections of the South. It does not limit its attacks to the cultivated varieties, for we have frequently observed it on wild plants, and even on the common Cinquefoil, a plant botanically related to the Strawberry.

The Strawberry-leaf Blight fungus was first studied with the view of tracing its life history by two French mycologists, the Tulasne brothers, some twenty years ago. They figured and described the forms, determined by them under the name of *Stigmatea fragariæ*, and by this name the fungus was known in Europe until 1882, when it was transferred to the genus *Sphærella* by Saccardo.‡ The same

*Trelease, 2d Ann. Rept. Wis. Exper. St., 1885.

†We have attempted to restrict the term "rust" to those diseases caused by species of the family *Uredineæ*, and "spot" diseases, to such as result from the attacks of parasites included in the genus *Phyllosticta*, etc., adopting the term "blight" for those caused by species of *Ramularia*, *Cercospora*, etc.

‡Syllog. Fung., I, 505.

author described the summer stage of the fungus in 1879 as *Ramularia Tulasnei*, and in 1883 the same form was published by Mr. Charles H. Peck under the name of *Ramularia fragariæ*. This stage of the fungus has been made the subject of papers by several American botanists, but none have attempted to trace the development of the other forms in its life history.

(*b*) EXTERNAL CHARACTERS OF THE BLIGHT.

Very small, deep purple or red spots appearing on the upper surface of the leaves are the first symptoms of this disease. These spots rapidly increase in size, and at the same time their color changes from purple to reddish-brown; eventually they become gray or white in the center, so that they finally present a gray or white central area surrounded by a dark purple border, shading off towards the healthy tissues to reddish-brown. The spots vary in diameter from one-sixth to nearly one-fourth of an inch, but it very frequently happens that several contiguous spots coalesce and form large, irregular-shaped blotches. The bright color which these spots impart to the leaves renders the latter particularly conspicuous, and this appearance is familiar to every strawberry grower (Fig. *a*). The leaves badly affected soon turn brown, this discoloration usually beginning at their tips, and become shriveled and finally die. Similar spots to those above described sometimes appear on the calyx and on the stems supporting the young berries or fruit.

(*c*) EFFECTS AND LOSSES.

The effect of the Strawberry-leaf Blight on the foliage of the plants, even in mild cases, must be detrimental to the processes of assimilation; and when the attack is severe it results in the early destruction and death of the plants. If the fruiting stems or leaves of the calyx are attacked the young berries never reach maturity, or the fruit becomes shriveled and unfit for use.

The injury to strawberry culture resulting from this disease appears to have been on the increase during the past five or six years, to the general alarm of the growers of this fruit. No special efforts have been taken to learn the actual extent to which this fruit industry has suffered from the ravages of the blight, but enough has been learned to demonstrate its gravity. In some localities the injury effected has been comparatively slight, while in others entire plantations have been completely destroyed. It appears that the disease is most severe in the States of Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, Kansas, and Kentucky. In southern Illinois, where there are more strawberries grown than in any other section of the country, the blight is deemed one of the worst enemies with which the cultivator of this fruit has to contend, and the losses sustained are often very great. A Connecticut correspondent states that in one year he lost $1,500 on a field of 6 acres from the Strawberry Blight. In Louisiana and other Southern States the disease is less destructive. This is probably due to the fact that in this section the plants are renewed every year, allowing no opportunity for the fungus to gain a foot-hold.

The attacks may occur at any time during the growing season under the proper weather conditions. Those coming early, if severe, injure the immediate crop, while later attacks may entirely destroy the prospects of a crop the year following. It is the opinion of some strawberry growers that the heavier the crop the more likely are the

plants to be attacked by blight after the fruit is gathered. The death of the plants before the close of the season sometimes results from these late attacks.

Some varieties appear to be more subject to the disease than others, but we are unable, at this time, to make any classification based on their degree of susceptibility. The following varieties have been mentioned* as among those most subject to the disease: Downing, Wilson, Russel's Prolific, Big Bob, Bidwell, Captain Jack, Forest Rose, and Manchester; those notably free are Crescent, Windsor Chief, and Sharpless.

(*d*) CONDITIONS FAVORING THE DEVELOPMENT OF STRAWBERRY-LEAF BLIGHT.

Heat and moisture favor the development of Strawberry Blight, and at any time during the summer when the weather is hot and moist the plants are likely to be attacked. Heavy dews or rains are essential to infection, but the disease may continue its work of destruction during dry weather; and it not infrequently happens that it develops in its worst form in dry, hot weather succeeding a period of frequent or heavy rains. The fungus causing the malady is truly parasitic in its habits, and, except that the conditions which may favor its development be inimical to the plants, the health or vitality of the latter does not enter into consideration. Other things being equal, plants, however vigorous and well cared for, are no less subject to the blight than those in feeble health.

In respect to the soil, the disease is undoubtedly most severe when the land is heavy or wet and undrained. We have in mind an instance which will illustrate this point. A plantation of about 5 acres was bordered on one side by a brook, towards which the land gradually sloped. For about 60 feet back from the brook the soil was marshy and wet, while the remainder of the field was fairly well-drained. The plants on the narrow strip of wet land were much more severely diseased with blight than those on the comparatively dry soil adjoining. The effect was like that sometimes observed when two varieties—the one resistant and the other susceptible to the disease—grow side by side. In the present instance there were a number of varieties planted in rows running at right angles to the brook, so that the greater severity of the disease on the wet land could not be attributed to any difference in susceptibility of varieties. The disease in the locality here noted appeared early in May, some ten days after a heavy rain-fall which was succeeded by damp, cloudy weather.

A deep and thoroughly well drained soil will supply sufficient moisture to keep the strawberry plants in good condition, but not enough to favor excessive development of the blight.

(*e*) BOTANICAL CHARACTERS.

The fungus causing the Starwberry-leaf Blight, although of microscopic size, is a plant like the strawberry itself, and consists of a vegetative and a reproductive system; the former is the mycelium or plant body of the parasite; the latter comprises the spores or reproductive bodies and the organs supporting or containing them.

The mycelium.—The vegetative part of the fungus is made up of slender, thread-like tubes which grow between and sometimes into the cells of the host. These threads are colorless (sometimes tinted

* Trelease in Second Ann. Rept. Wisc. Agr. Exp. Station, p. 48.

brown), flexuose, often anastosmosing, septate, and varying in diameter from $1\mu.5$ to $3\ \mu$ ($1\mu=\frac{1}{25000}$ of an inch). It is through the action of these mycelial threads on the cell contents of the host that the external characters of the disease, already noted, are produced.

Reproductive system.—The reproductive system of *Sphærella fragariæ* is quite complex, and although it has been studied very carefully it is not yet fully understood. From our examinations of the material at our disposal we have been able to determine three spore forms and possibly a fourth; the three of which we feel sure are conidia, spermatia, and ascospores. We are yet doubtful in regard to the pycnidia.

Conidia (Figs. *b* and *c*).—The best known and doubtless the most important reproductive bodies, economically considered, are the conidia. After the mycelium has grown for a time within the leaves and the light-colored central areas of the spots appear, the threads occupying this portion become massed together at frequent points just beneath the cuticle of either surface, and from these masses numerous short, colorless branches are sent out either through the stomata or ruptured cuticle, and it is upon their free ends that the earlier development of conidia takes place. The length of the branches varies a good deal, but usually ranges between 30μ and 50μ; they are sometimes composed of a simple elongated cell, but often they are divided by transverse septa into two to several cells. At a later period in the development of the fungus, conidia-bearing branches may arise from the perithecia, described below.

On the free ends of the branches the young conidia are developed, first as minute globose bodies, but, rapidly elongating, they soon appear as illustrated in Plate I, Fig. *b*. Sometimes a succession of spores, held together in a single series or chain by their contiguous ends, are formed upon a single stalk, and sometimes, though very rarely, two such series are developed from the apex of a common support. The free apex of the terminal conidium, whether it stands alone or forms one of a series, is obtuse and rounded; the other end and the extremities of those standing intermediate in a series are flattened at the points of attachment. Their length is from 20μ to 50μ, and they have a diameter of from 2.5μ to 4μ. Often only one-celled, they are frequently divided by transverse septa into two or three cells. They are colorless, like the stalks which support them, and are filled with a transparent, slightly granular fluid. The formation of these conidia continues throughout the summer, under favoring conditions of moisture and heat, and as they are exceedingly light and germinate readily in water, the rapid spread of the fungus and consequent disease over a plantation or section of country is easily understood. This stage of the fungus has been named *Ramularia fragariæ* by Charles H. Peck, and *Ramularia Tulasnei* by Saccardo.

At the approach of cold weather the formation of the conidia ceases, but the mycelium of the fungus remains alive in the tissues of the leaves, and in early spring a few warm days are sufficient to bring forth a new crop ready to spread infection at the first opportunity.

When the conidia are sown in water at a temperature of about 60° F., they will in a few hours send out slender germ tubes, which in-increase rapidly in length by continued apical growth. In forty-eight hours the germ tubes attain a length of many times that of the conidium from which they start, and are usually several times branched. Water is necessary to effect germination.

If, after a prolonged rain, a drop of water from a diseased leaf, or from an apparently healthy one growing close by, is examined with a good microscope, large numbers of conidia in various stages of germination will usually be seen. It is during such periods that the healthy leaves are infected; the germ tubes enter the leaf (either by directly penetrating the cuticle or through the "breathing pores"), and once within the tissue they may continue to grow independent of external circumstances.

Conidia sown on healthy leaves of pot-grown strawberry plants, which for three days following were kept constantly wet, produced the characteristic purple spots in about eighteen days. Similar sowings on leaves kept constantly dry were not infected, although the plants in both cases were cared for alike, except in the matter of moisture.

Repeated sowings of the conidia in solutions employed as fungicides were made. None germinated in a 1 per cent. solution of hyposulphite of soda, or in a one-fourth of 1 per cent. solution of sulphate of copper. A very small quantity of lime in water used in these experiments also checked the germination of the conidia.

Spermogonia.—During the autumn and early winter there is developed on the mycelium numerous round or ovoid bodies which, as they increase in size, break through the tissues of the leaf, appearing on the surface as minute black specks. Some of these bodies are the spermogonia, their interior being filled with spermatia. The spermatia have a length of 3μ, and are about three times as long as broad. They are produced in vast numbers and doubtless serve some important office in the economy of the fungus, but just what that office is has never been clearly demonstrated.*

Perithecia (Fig. *d*).—By far the larger number of the black bodies above mentioned are perithecia. They are the last to come to maturity, at the time the spermatia are most abundant their interior is filled with a clear mass of cells. They are usually somewhat larger (90μ to 130μ in diameter) than the spermogonia, and their outer walls are more nearly black and apparently thicker or firmer in texture. They are usually partially imbedded in the ruptured leaf-surface, but not infrequently they appear to be resting directly upon it. At the top of each there is a small opening or ostiolum which permits the contents to escape at maturity (Fig. *e*). If the perithecia be examined during the latter part of winter or early spring (they are almost always found abundantly on leaves destroyed by blight the previous year) the interior will be seen to be filled with numerous transparent sacs or asci attached to a thin layer of light-colored tissue resting on the botton wall (Fig. *e*). These sacs are about 50μ long and 10μ in diameter above, tapering below to a narrow base. Within them are formed the ascospores, usually eight in number in each sac (Fig. *f*). These are illustrated in Plate I, Fig. *g*, and are true reproductive bodies, designed, no doubt, to preserve the life of the fungus in special

*A fungus named *Septoria aciculosa*, often found associated with *Sphærella fragariæ*, has been thought by some to be the spermogonia of the latter, but its spores are often two-celled and they germinate without difficulty, contrary to the character of spermatia. Possibly it represents the pycnidial stage of the *Sphærella*, but this is very doubtful. *Septoria fragariæ* has also been thought by some to be the spermogonial stage of the *Sphærella*, but there is no longer any reason for supposing this to be the case. Another fungus (*Ascochyta fragariæ*), sometimes found associated with the *Sphærella*, has been regarded as its pycnidial form, but from our observations we can see no reason for accepting this view, although we have occasionally found this fungus on leaves destroyed by blight.

cases, but, as we have already seen, they are not essential to its perpetuation from one year to another. They are narrowly ovoid in shape, being more pointed below, and are divided into two cells by a transverse septum near the middle.*

Conidia-bearing stalks similar to those we have already described often grow in great numbers from the outer wall of the perithecium around the ostiolum, and like developments have been observed by us arising from similar parts of the spermogonia. These stalks produce conidia in every way like those which are formed in the early stages of the disease. By placing the old diseased leaves, upon which there are perithecia, in a moist atmosphere under a tumbler or bell jar the conidia-bearing stalks and conidia will grow from the latter in the greatest profusion.

From our studies of this fungus we conclude that its life history is limited to the developments above described: First, there is the mycelium, which endures throughout the year; second, the conidia, produced in the summer on short stalks arising from cushion-like masses of mycelium formed just beneath the cuticle. This stage appears to us to correspond to the pycnidial stage of the fungus of the black-rot of grapes, only, in this instance, the pycnidial walls are not developed, consequently the basidia and their spores are exposed; third, the spermagonia, which appear late in the season; and, fourth, the perithecia, with their asci and ascospores, found in early spring on leaves destroyed by the blight the previous year. The spore-forms are the summer conidia, the conidia which are produced on stalks that grow from the tops of the spermagonia and perithecia, the spermatia, and the ascospores.

The conidia are designed for the rapid propagation of the fungus, as shown by their great abundance and the ease with which they germinate. The ascospores, securely protected by the walls of the perithecium, are doubtless designed to perpetuate the fungus under conditions fatal to the life of the conidia.

(*f*) TREATMENT.

A knowledge of the habits of the fungus of Strawberry-leaf Blight shows us that the treatment of the disease must be preventive. The fungus, when once inside the leaf, can only be destroyed at the expense of the latter.

We can mitigate the evil and oftentimes wholly avoid it by pursuing special systems of culture. By annually renewing the settings and planting only in deep and thoroughly well drained soil loss from blight will seldom occur. Some have escaped the ravages of the disease by removing all the old leaves immediately after the fruit is harvested and cultivating the ground, at the same time adding some quick fertilizer. The easiest way to remove the leaves is to mow the beds, then rake the leaves together and burn them.

A simpler line of treatment, and one more likely to secure the desired result, is the application to the plants of some fungicide which will destroy or prevent the germination of the conidia falling upon the leaves. We have seen from our laboratory experiments, that these conidia will not germinate in very dilute solutions of hyposulphite of soda or sulphate of copper. It is a simple matter to apply similar solutions to the plants in the field, where it is only reasonable

* These ascospores are more elongated and rather more pointed at the narrow end than those figured by Tulasne, but they are certainly of the same species.

to suppose they will have a like action on the reproductive bodies in question.

Prepare the solution of hyposulphite of soda by dissolving 1 pound of the hyposulphite in 10 gallons of water. Apply with a convenient force-pump having a spraying nozzle of fine aperture.

The action of this remedy is immediate, hence it is necessary to apply it frequently during the season.

The sulphate of copper solution with carbonate of soda (described on page 331), or the following solution of ammonia calcarbonate of copper may be useful in treating this disease: In 1 quart of liquid ammonia dissolve 3 ounces of carbonate of copper, then dilute to 20 gallons.

These preparations of copper salts should be applied in the same manner as the hyposulphite of soda solution. They adhere very strongly to the foliage, and as the copper they contain dissolves very slowly their preventive action against the fungus lasts for a long time.

A solution of sulphide of potassium or "liver of sulphur" has been employed in combating the blight of the strawberry with encouraging results. Mr. R. E. Buffum, of the University of Virginia, writes:

> I sprinkled the strawberry plants with a solution made by dissolving 1 ounce of sulphide potassium in 8 gallons of water, repeating the operation several times before the berries ripened. This, I think, had a beneficial effect, as there was certainly a marked decrease in the amount of blight.

Prof. J. C. Arthur states in the Sixth Annual Report of the New York Agricultural Experiment Station, page 351, that—

> A part of a bed of Sharpless strawberries was sprayed four times with a solution of sulphide of potassium (one-half ounce to 1 gallon of water) with the object of holding in check the spotting of the leaves, due to the fungus *Ramularia Tulasnei*, often described as "sun-burn." The object sought was attained, as that part of the bed took on a more vigorous growth and showed fewer spotted leaves than the remainder. In fact, the difference between the sprayed and unsprayed portions was so marked that it seems unsafe to ascribe it wholly to the fungicide, it being better to content one's self with the strong indication that the sulphide is likely to prove a serviceable preventive of this disease, and to leave the question of its full efficiency to be determined by future trials.

As the value of whatever remedy may be employed, depends entirely upon its power to *prevent* the germination of the conidia of the fungus, the necessity of making the applications early is obvious.

(*g*) BIBLIOGRAPHY.

Arthur, J. C.: Sixth Annual Report New York Agricultural Experiment Station; 1888; p. 351.

Beckwith, M. H.: American Garden; December, 1886; p. 360.

Comes: Funghi in rapporto all, Economia domestica ed alle Piante agrarie; Naples, 1880; pp. 139, 140; Plate 33, Figs. 80, 81.

Earle, F. S.: Annual Report American Horticultural Society; 1885; Fungoid Diseases of the Strawberry; Fruit Grower's Journal (Cobden, Ill.). January 29, 1885; Vol. II, No. 16.

D'Arbois de Jubainville et Vesque: Les Maladies des Plantes cultivées; Paris, 1878; pp. 270, 271; Plate 5, Fig. 2.

Ellis & Everhart: Journal of Mycology, Vol. I, p. 75: *Ramularia Tulasnei*, Sacc.

Frank: Die Krankheiten der Pflanzen; Breslau, 1880; 607; *Sphæria fragariæ*, Fckl.

Kellerman, W. A.: Report Kansas State Horticultural Society; 1884; XIV.

Peck, C. H.: Thirty-fourth Report New York State Museum of Natural History; Albany, 1881 (issued December, 1883); pp. 30, 31; Plate 3, figs. 12, 15; *Ramularia fragariæ*, Pk.; Strawberry Ramularia.

Saccardo: Sylloge Fungorum; Vol. I, p. 505; 1882; *Sphærella fragariæ* (Tul.), Sacc.; Michelia, 1; p. 536; Sylloge Fungorum; Vol. IV, p. 203; *Ramularia Tulasnei*, Sacc.

Sorauer: Pflanzenkrankheiten; Berlin, 1886; pp. 367, 368; Plate II; *Sphærella fragariæ* (Tul.), Sacc.; *ibid*, 2d ed., II; p. 366; Plate 15.
Scribner, F. L.: Report U. S. Department Agriculture; 1885; p. 82.
Trelease, William: Second Annual Report Wisconsin Agricultural Experiment Station; 1885; pp. 47–58; 2 figures; The Spot Disease of the Strawberry Leaves; New York Weekly Tribune, June 13 and October 31, 1883; Preliminary List Parasitic Fungi of Wisconsin; p. 13.
Tulasne: Selecta Fungorum Carpologia; II; p. 286; Plate 31; *Stigmatea fragariæ*, Tul.; Ann. Sc. Nat. IV Ser. Tom. V; p. 112; *Sphæria fragariæ*.
Wallroth: Flora Cryptogamica Germaniæ; II; 767; *Sphæria fragariæcola*, Wall.
Winter: Krankheiten der Kulturgewächse; Leipzig, 1878; Rab. Kryp; Flora; II; p. 370.
Report Connecticut Agricultural Experimental Station; 1878; 108–111.
Strawberry Rust; New England Homestead; 1886; p. 287.
The Strawberry Fungus; Gardener's Monthly; XXVIII; p. 247.

2.—Apple Scab.

Fusicladium dendriticum.

(Plate II.)

(*a*) GENERAL OBSERVATIONS.

The disease of the apple caused by the fungus parasite *Fusicladium dendriticum*, has long been known to growers of this fruit as "Apple Scab." Less frequently we hear it spoken of as "black spot," or simply spot disease of the apple, or, when on the foliage, "leaf blight" or "leaf mildew." It has been known to botanists for a long time and has received many Latin names, but the one here adopted has been generally employed by mycologists since 1869.

The distribution of this disease is co-extensive with the cultivation of the fruit which it attacks, although there may be a few favored localities where it has not yet appeared. Throughout the Eastern and Central States one is almost certain to find it in every orchard, and on the Pacific slope in California it is also frequent. For more than fifty years it has been known in Europe. It has become a serious pest in Australia, and we now possess reports of its presence in New Zealand.

Closely allied species, or, perhaps, only forms of the Apple Scab fungus, infest our native thorn trees and other natives botanically related to the apple.

A fungus of such economic importance has, as may well be supposed, received much attention from our horticultural writers, and numerous papers relating to it are scattered through our horticultural journals and the reports of horticultural and agricultural societies. Some of the more important of these are mentioned below.

For a long time the fungus on the leaf causing the "leaf blight" or "leaf mildew" and that on the fruit causing the "scab" were regarded as distinct species. It was suggested by Prof. M. C. Cooke in 1873 that they were identical, and subsequent investigations have fully confirmed this view.

(*b*) EXTERNAL CHARACTERS OF APPLE SCAB.

On the leaves.—There first appear very small olive-green spots with a definite and rounded outline (Fig. 2). As these increase in size, their surface assumes a velvety appearance and their borders

become more or less irregular. The older spots vary from one-eighth to one-half an inch in diameter; frequently two or more spots may run together, forming large irregular blotches. Although most frequent on the upper surface of the leaf the spots sometimes appear on the under side, and the fungus often extends to the leaf petioles and young twigs, covering these parts with its dark, olive-green, velvety growth. When examined closely with a hand lens the spots on the leaves are seen to be made up of irregular threads radiating in all directions from a common center.

On the fruit (Fig 1).—The development of the spots on the fruit is similar to that which takes place on the foliage. They start from a center of infection and usually preserve a more or less rounded outline. As they increase in size the ruptured cuticle appears as a light-colored ring around their borders, and frequently flakes of the cuticle adhering to their surfaces imparts to them a more or less grayish appearance. The greatest vigor of the fungus is towards the margins of the spots, the central portion sometimes dying, and the apple beneath, in its efforts to recover from the disease, forms a corky layer which appears as a roughened, russet-like surface.

(c) EFFECTS AND LOSSES.

Through the action of the parasite on the leaves there is an unequal development in the two surfaces, causing a greater or less distortion of these organs and, when badly affected, their power of assimilation is destroyed. Its injury to the twigs or young shoots, when these are attacked, is often quite serious in its character. It is on the fruit, however, where it produces the dark olive-green or black spots so well known to every orchardist as "Apple Scab," that the fungus causes the greatest injury. At no period of its growth is the apple exempt from the attacks of this parasite, but the most damage is occasioned when the fruit is infested early in the season. Sometimes, when the apples are no larger than peas, the fungus of the scab may be found upon them, not infrequently enveloping their entire surface, and practically checking all further development. When less severely attacked the apples may continue to grow, even to maturity, but the result is knobby, misshapen fruit of inferior quality. If the attack is made towards the close of the season the fruit may attain its full proportions and quality of flavor, but the spots, disfiguring its surface, render it unsightly and depreciate its market value.

Under ordinary circumstances there are some varieties which escape the scab, but in some seasons, however, it respects neither condition of soil, mode of culture, nor variety of fruit.

The varieties reported to be comparatively free from the disease are the Russets, Ben Davis, Winesap, Willow Twig, Jonathan, Rawle's Janet, Smith's Cider, Maiden's Blush, Grimes' Golden, York Imperial, R. I. Greening, Sops of Wine, Duchess.

Those especially subject to its attacks are White Winter Pearmain, Huntsman, Northern Spy, Early Harvest, Carolina Red June, Fameuse, Baldwin, Hass, etc.

It must be said, however, that varieties notably free from disease in one section when grown in some other locality more or less remote may scab badly.

The Bellflower comes into the markets in Washington nearly free from scab some seasons, while in others it is very badly affected, and

the same fact has been observed in regard to some of the varieties named in both the above lists.

In response to letters sent out by this section relative to the prevalence of "scab," a number of prominent horticulturists in different sections of the country have furnished interesting information relative to the extent of the injury occasioned by the disease, varieties affected, etc. In several States the extent of loss is reported to amount to fully one-half of the crop, while reports from other States place the annual loss at from one-fourth to one-sixth of the crop.

A. J. Hammond, secretary of the Illinois Horticultural Society, estimates the loss from this cause in each county in his State at 20,000 bushels, which, at 20 cents per bushel, gives a loss of $4,000 per county, or about $400,000 for the entire State. Secretary Goodman, of Missouri, estimates the loss in his State to be one-half the crop. Secretary Brackett, of Kansas, places the annual loss in that State, one year with another, at one-fourth of the crop. Mr. Ragan, secretary of American Pomological Society, places the annual loss from Apple scab in Indiana, at about one-sixth of the crop.

Under date of November 11, 1886, Mr. Charles S. Pope, president of the Maine Pomological Society, writes as follows:

Five years ago our individual loss from this disease was at least $1,000, and this year we hear of injury to the apple crop from this cause in many parts of the State. The apples begin to show the "scab" before they are half-grown, and frequently all growth is stopped, and the fruit shrivels and becomes worthless. If not badly affected the fruit makes fair growth, but it is so much injured that the apples begin to decay under the spots early in the season.

Perhaps you may think that I exaggerated a little when I stated that we lost $1,000 in one season from this disease, but I will show you how I arrived at my conclusions. In 1881 we harvested nearly 3,000 bushels of Baldwins, of which about 2,000 bushels were so badly affected that we kept them in separate bins, and not over half of them were suitable for No. 1 apples; the diseased apples were sold for 25 cents less per barrel than the best ones. Now, the affected apples were not more than half-grown; in fact, the apples on many trees were so small that we shook them off and threw them in with the cider apples. We sold the 2,000 bushels of affected apples for about $1,200; had they been free from "scab" and attained full size, or 4,000 bushels, they would have been worth from $3,000 to $3,500. With this estimate the loss was more than $2,000. I call to mind one season when we lost more than half our crop about midwinter by rotting. The apples began rotting under the "scab" spots and eventually the fruit entirely decayed.

(*d*) THE CONDITIONS FAVORING THE DEVELOPMENT OF THE SCAB.

The fungus of the Apple Scab appears to be retarded in its development by the heat of summer. Its most rapid growth takes place during moist, cool weather, such as usually prevails during the early months of spring or autumn. It may be observed that spots which during the hot summer months remain brown, at the approach of cool weather assume the olive-green, velvety appearance indicating a renewed activity on the part of the fungus. The parasite doubtless retains its vitality through the winter, both on the twigs in the orchard and on the fruit which it infests. We have seen specimens of the latter in midwinter in the markets of Washington covered with spots on which the fungus was in a most flourishing condition. From the ease with which we know it can be propagated to healthy fruit, and from the appearance of apples in the public markets in the winter and spring months, we believe that the disease may spread after the fruit has been harvested and placed in storage. It is a well-known fact that apples, after being gathered and stored, undergo a sweating process, and if healthy and diseased fruit are in contact during this period, infection of the former is very likely to follow.

It is also well known that the "scab" fungus is most severe in its attacks in seasons when damp, cold weather prevails at the time the fruit is forming. In the spring of 1885 the young fruit was closely watched for the first appearance of the "scab" by my assistant, Mr. Galloway, then at Columbia, Mo. It was noted that at the time the young apples were about the size of peas a period of cold, damp weather set in. In a few days many of the varieties showed plainly the minute black specks which mark the first appearance of the fungus; later these developed into the well-known "scab" spots. The spring of 1886, in the same locality, was very dry and warm, and there was a marked absence of the *Fusicladium*.

The character of the soil appears to have little influence over the disease, although in heavy soils, particularly where the subsoil is wet or poorly drained, it is naturally more prevalent than in light or well drained lands. A damp, cool atmosphere rather than an excess of moisture with heat appears to be most favorable for the development of this malady.

(e) BOTANICAL CHARACTERS.

Mycelium.—In thin sections the mycelium or plant body of the fungus—the vegetative portion—appears like a dense mass of tissue composed of dark brown-walled cells. It does not penetrate the tissues of the host, but grows between the cuticle and the epidermis. It sometimes occupies the cells of the epidermis, especially in the fruit, and not infrequently the epidermal layer is entirely destroyed by it, the fungus resting directly on the tissues beneath. Its effects are confined to a few underlying layers of cells. These are shrunken and have their walls and contents browned. The growth of the fungus soon distends and breaks the epidermis. From the exposed surface there arise short (40μ to 50μ) upright brown threads upon which the reproductive bodies or spores are borne (Fig. 3).

Reproductive bodies.—The spores (Fig. 4) are of the same color as the upright threads or stalks supporting them. They are usually oval in outline, though not infrequently egg-shaped or pear-shaped, and vary a good deal in size. Their average dimensions are 10μ by 20μ. Generally simple or one-celled, they are occasionally divided into two cells by a transverse wall or septum. Aside from the power of reproduction which the fungus possesses in these spores, it appears that the individual cells composing the plant body of the parasite may serve a similar purpose. These, under favoring conditions, will push out germ tubes, if we may so apply this term here, which develop into new individuals of the species. This method of reproduction may be roughly compared to that by root cuttings in some of the higher plants.

Germination of spores.—The spores germinate rapidly in water, or even in an atmosphere saturated with moisture. The surface of many scab spots on the White Winter Pearmain, purchased in the Washington market in December, were found to be covered with vast numbers of germinating spores, the filamentous germ tubes everywhere covering the spots with a vigorous growth. The appearance of spores in germination is illustrated in Fig. 4, Plate II.

The germ tubes are rather thick, nearly of the same color as the spore, and frequently divided by cross-walls or septa. When the free end of the germ tube comes in contact with any obstruction it usually

thickens and pushes out lateral or side branches from the swollen points.

A number of experiments have been made in the laboratory in germinating the spores of *Fusicladium* in various solutions and at different temperatures. It was found that they germinated most readily in pure water at a temperature of about 50° F., the time required usually being about eight hours. In thirty hours the germ tubes attained a length many times that of the spore. Under certain conditions, not well understood, the filaments developed secondary spores at their tips, and these in turn germinated like the original spore.

When subjected to a comparatively high degree of temperature, and all water removed, growth in the germinating spores ceased, but was renewed at once upon being restored to the favoring conditions of heat and moisture, even after the lapse of four or five days.

Repeated sowings of the spores made in solutions of sulphate of copper of various strengths, showed that a one-fourth of 1 per cent. solution would effectually prevent germination; in a one-eighth of 1 per cent. solution about 10 per cent. of the spores germinated, but they made only a feeble growth.

In the study of the diseased White Winter Pearmain, mentioned above, there was unmistakable evidence of the penetration of the cuticle by the germ tubes. As an experiment, some germinating spores were sown on the healthy surface of one of the apples and then kept moist under a bell-jar. In ten days it was found that the germ tubes had penetrated the cuticle in several places, and made a considerable growth in the cells of the epidermis. This penetration was evidently effected by a dissolving or eating away of the cuticle through some corrosive action on the part of the germ tubes. The possibility of infection of healthy fruit from that which is diseased in the same barrel thus appears to be evident.

This reproduction by the spores, joined with the independent growths which may arise from the individual cells of the plant body, afford ample provision for the propagation of the fungus. No other form of this fungus is known than that which we see in the "scab" of the fruit or "mildew" of the leaf, nor does any other form seem to be necessary for the continued existence of the species. The fungus is doubtless perennial, living on the fallen leaves, but more especially on the fruit and young shoots during the winter, and the low temperature at which the spore-formation takes place, insures its early propagation and dissemination in the spring.

(*f*) TREATMENT.

The fungus of the Apple Scab does not penetrate into the tissues of the host, and very early in its development it is wholly exposed to any application which may be made to destroy it. It appears, however, that the vegetative portion or plant body of this, as well as of many other fungi, is very resistant to the action of chemical re-agents quite as much or more so than are the tissues of the leaf or apple upon which it grows. We can scarcely hope, therefore, to accomplish its destruction, unless it be the growths infesting the young shoots and the scales of buds. Before the latter expand in the spring much stronger solutions can be applied than it is possible to use later in the season, and it is at this period that the warfare against this fungus should begin. It has been observed that the germination of the spores is

wholly prevented in very dilute solutions of sulphate of copper, and our chief dependence in combating this disease appears to rest upon this fact—the possibility of preventing the germination of the spores where they can do harm. A practical treatment has been discovered by which we may prevent the germination of the spores of the downy mildew of the grape-vine by applying various solutions of sulphate of copper to the surfaces of the leaves upon which the spores of the fungus fall. It is doubtless equally practical to accomplish by a similar treatment, a like result in the case of the *Fusicladium* of the apple. Experiments already made with the sulphate of copper solutions indicate that they will, when properly applied, at once check the "scab." Further and more systematically conducted experiments are required in order to determine fully what preparation is most efficacious, at what season it is best to make the applications, and the strength to which the solutions must be limited. Where eau celeste, prepared according to the original formula, has been tried it has severely burned and injured the foliage. This preparation may be rendered less caustic by the addition of ordinary carbonate of soda, or by being prepared as directed on page 331.

Another and more simple modification of the eau celeste is prepared by dissolving in 1 quart of liquid ammonia 4 to 6 ounces of carbonate of copper, then dilute with water to 25 gallons. The ammonia and carbonate of copper solution may be kept in a bottle and diluted when required for use at the rate of about 1 ounce of the solution to the gallon of water. Those who have used this preparation on the grape-vine say it is perfectly harmless to the foliage and is as efficacious against mildew as eau celeste. It is simple and easily prepared and is very strongly adherent to the foliage.

Simple solutions of sulphate of copper ought not to be employed during the growing season as their use is almost certain to result in injury to the foliage. The Bordeaux mixture (see page 328) may be used at any time without fear of injury.

Using one or the other of the above preparations, the following course of treatment is suggested:

(1) In early spring, before the buds have commenced to expand, spray the trees thoroughly with a solution of sulphate of iron, using 4 pounds of the iron sulphate to 4 gallons of water.

(2) As soon as the fruit has set, apply the Bordeaux mixture or one of the modified preparations of eau celeste.

(3) If the weather should be such as to favor the development of the "scab" fungus, a third application should be made two or three weeks after the second, using the same materials.

In addition to the effect that these applications may have on the development of the fungus, they will doubtless serve to keep off many insect pests.

In storing the fruit for winter, especial care should be taken to separate all the apples showing any signs of the scab from those which are smooth and healthy, and they should all be kept in rooms or cellars free from moisture.

The Nixon's pumps, or Field's force-pump, are good appliances for spraying the simple solutions and eau celeste, and, substituting the nozzles furnished with these for the Vermorel nozzle, they may be employed to apply the Bordeaux mixture. In employing solutions containing sulphate of copper it is essential that the pumps be made of copper and the valves should be made of rubber; if the latter are of leather they ought to be oiled frequently during the applications.

Iron is quickly corroded and leather soon destroyed by the caustic action of the copper salt.

Experiments have been made in treating the *Fusicladium* of the apple with a solution of hyposulphite of soda, 1 pound of the sulphite to 10 gallons of water, by Mr. E. S. Goff, of the New York Agricultural Experiment Station. He made applications to one tree only, a Siberian crab, which had for several years been so much affected with the fungus as to render the fruit entirely unfit for use. Applications were made to one-half of this tree May 5, 9, and 15. The result was that on the sprayed part of the tree the per cent. of uninjured fruit was double that on the unsprayed part, while the per cent. of third quality or much injured fruit was one-half less.

The year following the same tree was again treated, four applications being made, viz, April 22, May 6, 10, 17. The strength of the solutions in the first three applications was 1 pound hyposulphite to 10 gallons water; in the fourth the solution was reduced one-half. The part of the tree sprayed bore a fair crop of medium-sized fruit, while on the unsprayed side the apples were so affected by the fungus that none matured.

This remedy is cheap and easy of application, and, should it generally prove to be as effective as in the case here cited, its value can scarcely be over-estimated. It does not possess the lasting preventive qualities of the preparations of sulphate of copper, as its action is immediate, and, other things being equal, preference should be given to the copper compounds.

(*g*) BIBLIOGRAPHY.

Arthur: Report New York Experiment Station; 1884; p. 370.

Berkley: Gardener's Chronicle; 1884; p. 368; Sub. *Cladosporium pyrorum.*

Burrill: Transactions Mississippi Valley Horticultural Society; 1883; pp. 202–207; Agricultural Review (New York), November, 1882.

Cooke: Grevillea II; p. 64; Sub. *Spilocœa pomi.*

Eriksson: Bidrag Vara odlade vaxters sjukdomar; Vol. I; p. 61.

Frank: Die Krankheiten der Pflanzen; Breslau; 1880; p. 587; fig. 106.

Fries: Systema mycologicum; vol. 3; p. 504; Sub. *Spilocœa epiphylla.*

Galloway: Annual Report Missouri State Horticultural Society; p.—; 1886.

Goff: Fifth Annual Report New York Agricultural Experiment Station; p. 177.

Klee, W. G.: Biennial Report California State Board Horticulture; 1885–'86; pp. 408–413; figs. 1–2.

Pammel, L. H.: Prairie Farmer; 14th November, 1885.

Peck: Thirty-fourth Report New York State Museum of Natural History (1881); p. 32; pl. 4; figs. 1–3.

Penhallow, D. P.: Twelfth Annual Report Montreal Horticultural Society; p. 20.

Saccardo: Sylloge; vol. 4; p. 345.

Sorauer: Monatsschrift des Vereins zur Beförderung des Gartenbaues in den königl. preuss. Staaten; 1875; XVIII; pp. 5–15; pl. 1. Ueber die Entstehung der Rostflecken auf den Früchten des Kernobstes; Tageblatt der 47. Versammlung deutscher Naturforscher und Aertze in Breslau vom 18. bis 24. September, 1874, Breslau, 1874, s. 84. Aftrycht i Botan. Zeit.; 1875, s. 50. Handbuch der Pflanzenkrankheiten. (1886) II, s. 392. Die Obstbaumkrankheiten; Berlin; 1882; s. 100, etc.

Trelease: First Annual Report Wisconsin Experiment Station; 1884; p. 45–56; 3 figs. Report Minnesota State Horticultural Society; 1886; p. 52. Parasitic Fungi of Wisconsin; No. 101.

Von Thumen: Fungi Pomicoli; pp. 15–17; pl. 2, fig. 2; Wien; 1879; p. 15.

Wallroth: Flora cryptogamica Germanica; 1833; Sub. *Cladosporium dendriticum.*

3.—Bitter-rot of Apples.

Glœosporium fructigenum, Berk.?

(Plate III.)

(a) General remarks, extent, and severity.

During the past year a number of fruit-growers in the Southwest have complained of a rot of the Apple which was seriously affecting their crops. In parts of Arkansas the disease was said to be very injurious, frequently causing the entire destruction of the fruit.

Mr. J. W. Beach, a successful fruit-grower of Batavia, Boone County, Ark., relates his experience with this disease as follows:

> I came to this county in 1884, and that season there were four trees in my old orchard affected, two of which were Fameuse. The man from whom I purchased my place told me that the Fameuse had always been subject to the rot. For the last three years the disease has steadily increased, so that this year (1887) my old orchard of 75 trees will not yield 25 bushels of sound apples. I have talked with a great many orchardists in regard to the trouble, and they all agree in the opinion that the old orchards are the most affected. I have lately visited fine orchards of hundreds of trees, but in no case did I find the fruit perfect; all were more or less diseased.

From the information received it appears that the rot usually begins early in the summer and increases as the season advances. When once affected the fruit never recovers, but continues to decay until completely destroyed.

The rot may develop after the apples are harvested and stored for the winter, and also spread from the diseased to the healthy fruit by contact. All varieties are alike attacked, and the development of the malady is not influenced by the system of cultivation pursued or by the character of the soil. At Denison, Tex., our attention was called to this disease through the large amount of fruit destroyed by it. It begun while the apples were yet upon the tree, and in some cases the brown patches on the fruit suggested the idea that they might result from sun scald, but an examination of the diseased tissues, as well as subsequent developments, point to another cause.

This rot is caused by a fungus that belongs to a group the members of which are frequently quite destructive, one species causing the socalled anthracnose of the vine, while another attacks the raspberry and blackberry. The members of the group as a whole, are known to botanists as *Hyalosporœ*, and the species which causes the Apple rot we are describing, we think is *Gleosporium fructigenum*, Berk. So far as we have been able to discover, the first account of this fungus was published in the Gardener's Chronicle by the Rev. M. J. Berkley, more than thirty years ago.* Several subsequent writers on plant diseases have briefly referred to it.

Serious and wide-spread as this disease seems to be in certain parts of the United States, we do not find in the works of our mycologists any record of the fungus that causes it.

(b) External characters.

The affected apple at first shows one or more black or, usually, brownish spots on any part of the surface; as these gradually enlarge their shape becomes more or less circular and their borders somewhat

* Gardener's Chronicle, 1856, page 245.

sharply defined. Sometimes the spots coalesce or run together, and in this manner the entire apple is soon affected. Toward the center of the diseased spot there is usually a very dark, frequently almost black, discoloration.

Upon close examination it is seen that the darker portions are studded with minute black points, which are slightly raised above the surrounding tissue, imparting to their surfaces a somewhat roughened appearance; occasionally these points are arranged in circles or grouped in little clusters.

On cutting through a diseased apple while the spots are small it is seen that the decaying tissue extends to quite a distance into the fruit, and as the growth of the fungus continues the entire apple soon becomes a soft, yellowish-brown mass.

(c) BOTANICAL CHARACTERS OF THE FUNGUS.

The body of the parasite, or the mycelium, consists of slender threads, which push their way through the tissue of the fruit and destroy the parts with which they come in contact. These threads vary in size and color. At first they are nearly transparent; later, however, they become darker, and when old they are usually brownish-black and somewhat thickened.

Frequently the thicker tubes send out lateral branches, which are at first colorless. These are divided by more or less frequent transverse partitions or septa, and soon assume the usual brownish color. The walls of the tubes are constricted at the septa, so that when the latter are roughly handled they frequently break apart at these points. In the process of growth the mycelial threads become thickly matted and interlaced at certain points, and as these mats become more compact they gradually take a more or less globose shape. Transverse sections through a portion of a diseased spot will reveal these little rounded masses in all stages of development.

Their formation begins at a point some distance beneath the epidermis, and as they continue to enlarge they finally rupture the latter and appear on the surface in the form of the minute black specks already described. A thin transverse section through one of the mature black pustules shows their structure. With the aid of the microscope it is seen that they consist, for the most part, of compact, dark-colored, many-septate threads, which are arranged with their ends pointing towards or frequently protruding through the ruptured cuticle. Before the cuticle is ruptured this arrangement is not so apparent as the mass at this time has a rounded form. When the cuticle is torn, however, the hitherto globose mass spreads out and becomes somewhat fan-shaped above (see Fig 2).

Upon the tips of the closely-compacted threads spores, or reproductive bodies, are borne (Fig. 3). These are colorless, or nearly so, and somewhat variable in shape; usually, however, they are more or less cylindrical, rounded at each end, and, occasionally, somewhat curved (Fig. 3, B).

Each thread develops a single spore, but the former are so thickly compacted that an immense number of the latter are developed in each pustule. When sown in water the spores germinate within ten hours by sending out one or more rather thickish germ tubes (Fig. 5). When first sown there are usually no signs of nuclei in the spores. Just before germination, however, nuclei (or vacuoles) appear, and the contents of the spore become granular.

The germ tubes continue to increase in length without further change for about twenty hours, when there appear upon the free ends slight swellings, which gradually enlarge and become more or less globular and dark colored. When full grown these bodies are about 8μ in diameter, and soon after attaining this size they germinate in a manner similar to that of the original spore.

The tubes from these secondary spores continue growing and ultimately develop the same kind of bodies from which they were derived, and this process continues as long as moisture and heat are furnished (Fig. 4).

On the 18th of November, 1887, spores taken from a diseased apple were sown in several places upon the cut surface of a healthy Winesap. Spores were also sown at the same time upon the uninjured surface of the same specimen. Six days later the brown spots where the spores were sown upon the cut surface were one-half an inch in diameter, while no effect whatever was produced where the sowings were made upon the uninjured surface. These experiments were repeated a number of times, but in no case did we succeed in infecting the apple where the spores were sown upon the uninjured surface.

Infection was readily secured by inserting a knife blade first in a diseased apple and then in a healthy one. About eight days after the spores are sown the little black pustules usually appear, showing that reproductive bodies have again been formed.

There is frequently found at the base of the spore-bearing threads a rather thick and dark walled cavity (Fig. 2), which, as seen in a cross-section, shows a clear zone completely filled with minute, colorless, oblong bodies borne upon slender, transparent basidia or stalks that spring from the surrounding walls.

These sacs or conceptacles are called pycnidia, a name determined by their contents. What may be their rôle in the economy of the fungus is a matter of question. It is probable, however, that they aid in some way in the propagation of the fungus. The spore-bearing threads first described, spring directly from the walls of the pycnidia, and it is probable that they live through the winter in the decaying fruit, as we have found them in abundance in January, and at this date they developed a great number of spores when placed in a warm, moist atmosphere.

From the foregoing account of the disease and its cause, it will be readily understood that we have a dangerous foe to contend with, but with our present limited knowledge of its habits it is impossible to suggest means of combating it.

4.—The Rust of Beets.

Uromyces betæ, Pers.

(Plate III.)

(*a*) GENERAL OBSERVATIONS.

This disease is not a new one to other countries, and the life history of the parasite causing it was followed through by Kühn as early as 1869, while the summer form was described as *Uredo betæ* by Persoon, and the winter stage as *Uromyces betæ* by Tulasne earlier than this. The discovery of the æcidio-stage is due to Kühn

(1869). It is a well-known malady both in France and Germany, but is not serious enough to call forth much notice in the agricultural journals. This is probably due to the fact that it occurs only in isolated places and is easily controlled; for it attacks both the sugar and fodder beets, and the diseased leaves soon turn yellow or brown* and are not even good for fodder. It is supposed that it somewhat diminishes the amount of sugar produced in the countries where it exists; and a French scientific work† of 1878 states that it had been on the increase for several years.

(b) THE DISEASE IN CALIFORNIA.‡

In September, 1887, at Orange, in the southern part of California, the leaves of the cultivated Beet were found attacked by this Beet rust. The infested leaves were thickly dotted with powdery, round or oval, raised, reddish-brown spots, surrounded by a white rim formed of the ruptured epidermis, and varying in size from mere points, scarcely visible to the naked eye, to spots slightly over a millimeter in diameter. They were irregularly distributed over both surfaces of the leaf, sometimes occurring exactly opposite each other. Some of the spots were surrounded by a small area of dead tissue.

Dr. Byron D. Halsted § states that he found this rust at Santa Barbara, where it "was making much trouble for the market gardeners. In some places every leaf of the plant was badly infested and whole rows of beets were dwarfed and discolored by the parasite. The pest was found in its worst form on the escaped plants which in some places almost cover the moist low ground."

(c) MICROSCOPICAL CHARACTERS OF THE FUNGUS OF BEET RUST.

Upon examination with the microscope these effects were found to be caused by a fungus belonging to the family *Uredineæ*. Investigations of many members of this group by various observers have demonstrated that they are polymorphic, *i. e.*, possessing two or more forms of spores or reproductive bodies, and these forms may or may not develop upon different hosts. In the case of the fungus of the rust in question, all these forms are found upon the same host, each kind having a particular time of the year for its appearance, following a regular succession in development.

Æcidio-stage.—The form which occurs earliest is the æcidio-stage. This has two kinds of receptacles, the æcidia and the spermogonia, the latter appearing slightly earlier than the former. These forms appear in the spring upon the leaves and petioles, developing just beneath the cuticle. They at first form raised places upon their surfaces. The epidermis is soon ruptured and the spermogonia and æcidia are exposed, appearing as clusters of spores surrounded by a white envelope having the shape of a bowl or cup. The æcidiospores are orange-yellow, arranged in chains, and set so close together that, by mutual pressure, they have a polygonal form. These æcidiospores are developed from short, upright basidia at the base of the cup. When brought upon the surface of the leaf, under favorable

* Frank, Die Krankheiten der Pflanzen.

† Jubainville et Vesque.

‡ Its presence in California is noted by Rev. J. E. Vize, in Grevillea, Vol. V, (1876–'77), p. 110.

§ Bulletin from the botanical department of the Iowa State Agricultural College, 1888, p. 115.

conditions, they give rise to germinating filaments which enter the leaf through the stomata and form a mycelium in its tissues. In its growth this mycelium winds through the intercellular spaces (Plate III, Fig. 10), and obtains sufficient food for its development by means of haustoria which it sends into the cells.*

Uredo-stage.—At a definite period these mycelium threads form compact masses in certain places beneath the epidermis, and from these masses arise short, upright hyphæ or basidia, each of which bears a single spore upon the end (Plate III, Fig. 10). The spores, increasing in number and size, rupture the epidermis (Fig. 10 *b*), and when ripe escape by falling from their basidia, which, in this case, are known as pedicels (Fig. 10 *d d*). This is the summer or uredo form of the fungus, and its external appearance has been already described.

The uredospores (Fig. 11) are round or ovate, dark yellow, with a somewhat thickened wall and an echinulate surface, upon which one or two bright places may be seen. These bright spots are caused by perforations in the endospore or inner layer of the wall, and it is through these perforations that the young, growing hypha protrudes in germination (Fig. 11 *a*).

Teleuto-stage.—These germ filaments bore through the epidermis* and form a mycelium like that developed from the æcidiospores in form, manner of growth, and function. The uredospores are produced in this manner for several generations, but as autumn advances spores of another character appear among them. This third form is also unicellular, but darker in color and thicker walled than either of the others. It has a smooth surface, and opposite to the attachment of the pedicel there is a thin place in the wall that affords a point of least resistance to the germinating hypha. When ripe these spores fall off, carrying with them the pedicels which become detached from the stoma beneath. The name teleutospores is applied to this third form, and they may occur mingled with the uredospores or form independent spots. In the latter case they occur upon the petiole.† The teleutospores are the resting or winter spores of the fungus, and, although appearing in the fall, they do not germinate until the following spring after a winter period of rest. The germinating tube pushes through the thin place in the wall opposite the point of attachment of the pedicel and forms a short branched hypha or promycelium. From the end of each branch small buds or sporidia are cut off by a special process. These are capable of germinating and producing a mycelium in the plant tissues, and this in turn reproduces the spermogonia and æcidia, thus completing the alternation of generations.

It will be seen that the life history of this fungus is the same as that of other *Uredineæ*, but it differs from the other genera of this group in that its winter spores are unicellular. It closely resembles *Uromyces rumicum*, found upon sorrel, but, so far as known, it has never been found upon any host but the Beet, and this renders the matter of subduing it comparatively easy. Since the teleutospores do not make their appearance until autumn, and as the carrying the fungus over winter is believed to depend upon the teleutospores the thrifty cultivator will watch for the earlier stages of the

* Sorauer, Pflanzenkrankheiten.
† Frank, Die Krankheiten der Pflanzen.

fungus and carefully collect all leaves showing any sign of infection and burn or otherwise destroy them.

(*d*) TREATMENT.

We are not aware that any direct mode of treatment has been successful in the case of fungi of the family *Uredineæ* to which the Beet rust fungus belongs. If the annual infection is dependent upon the teleutospores we should seek to prevent, as far as possible, their formation. The only spores which are produced entirely independent of the host are the sporidia, which are the product of the germination of the teleutospores. These sporidia are very delicate and exceedingly minute bodies, and if means can be devised for preventing their coming upon the young beet plants, or, should this not be possible, a way discovered to prevent their germinating and entering the leaf tissues by the application of some fungicide (dilute solution of chloride of iron), the disease may be wholly, or in part prevented.

(*e*) BIBLIOGRAPHY.

Winter: Rabenhorst's Kryptogamen Flora; I; 1885; p. 155.
Sorauer: Pflanzenkrankheiten; Zweite Auflage; II; p. 228.
A. D'Arbois de Jubainville et Julien Vesque: Les Maladies des Plantes Cultivées; p. 171.
Frank: Die Krankheiten der Pflanzen; II; p. 469.
Kühn: Botanische Zeitung, 1869; Zeitschr. des Landw. Centralver. d. Prov. Saschen, 1869; No. 2.
Persoon: Synopsis; p. 220.
Strauss; (*Uredo cincta*) Wetrerau Annal.; II; p. 96.
Vize, J. E.: Grev; V; 110.
Cooke, M. C.: Grevillæ; VII; 137.
Halsted, B. D.: Bull. Iowa Ag. Coll., 1888.

5.—Leaf Rust of the Cherry, Peach, Plum, etc.

Puccinia pruni-spinosæ, Pers.*

(Plate III.)

(*a*) GENERAL OBSERVATIONS, DISTRIBUTION, ETC.

The Leaf Rust here described is wide-spread in this country, having been observed in nine States, including Massachusetts, Florida, Louisiana, Texas, and California, a fact which would indicate a very general distribution. It is also known in Germany, France, and Great Britain. In the first-named country it is popularly called the "rust of the stone-fruit trees."†

With us it is most generally found upon the plum, but occurs also on the cherry, apricot, and peach. It has been described as the "plum tree brand."

The fungus producing the rust has been described under several different names; that used here is the one adopted by Winter. Some confusion has probably arisen from the fact that the uredo stage alone occurs upon the peach and from the resemblance of the uredospores to the teleutospores of *Uromyces*.

The uredospores may or may not be present on the plum,‡ but on the specimens examined a few have been found in all cases mingled

*The more important synonyms are *Puccinia prunorum*, Lk., *Uredo prunastri*, D. C., and *Uromyces prunorum*, Fckl.

†Frank, Die Krankheiten der Pflanzen, p. 486.

‡Peck, XXV, p. 116.

with the teleutospores. Some leaves gathered in Aiken, S. C., in April had nothing but uredospores but they seem to persist until winter, as specimens collected December 26, in Texas, still showed a large number. The climate may, of course, have something to do with their presence.

(*b*) EXTERNAL CHARACTERS.

The appearance of the diseased leaves differs according to the species attacked. On the Peach small, round, powdery spots of a yellowish-brown color make their appearance upon the lower surface of the leaf, and directly opposite these, upon the upper surface, the tissue turns reddish-yellow. So far as known this appearance does not change throughout the year, except that as the spots grow older they may turn brown upon the upper side. The Plum may have similar spots early in the season, but later these are mingled with dark, purplish-brown, powdery spots below, and above they may be yellow or dark brown. The spots are irregularly scattered over the leaves and sometimes confluent.

(*c*) MICROSCOPICAL CHARACTERS.

The fungus of this disease, like that of the Beet Rust, belongs to the family *Uredineæ*, but in this case the æcidio-stage of the parasite is not known. The known spores, which have strongly marked specific characters, are formed upon a stroma beneath the epidermis, which they finally rupture, and they, together with the stroma, project slightly above the surface. The spores are interspersed with paraphyses (Fig. 8), having expanded globular tips with walls thickened at the apex, giving them the appearance of immature uredospores. The uredospores (Figs. 6 and 7) are light yellow in color and of a very irregular form, varying from club-shaped to oblong, but are most often obovate; the walls are thin except at the apex, where they are greatly thickened; the surface is echinulate, but the spines diminish in size towards the apex, and are scarcely visible upon the thick part of the wall; the endospore is pierced by two germ pores (Fig. 7, *c c*) situated just below the thickened portion of the wall.

The teleutospores (Fig. 9) are dark-brown, two-celled bodies, so strongly constricted in the middle that the cells are usually about the same size, but the upper one is sometimes larger, and the lower may be colorless in some cases. The wall is of unform thickness, and is covered with short, thick spines, set very close together.

Both teleuto and uredospores have comparatively short pedicels. The former have never yet been found upon the Peach, and it is probable that they do not occur upon it at all, since specimens gathered in Texas as late as December 26 failed to show any.

In regard to the disastrous effect of this fungus on the Peach a Texan correspondent writes, October 18, that "the fungus caused nearly all the leaves to fall within the last four week, even the second growth."

The wild as well as the cultivated plums are attacked, a fact that will render infection of cultivated trees certain when there are diseased native ones in the vicinity.

(*d*) TREATMENT.

Little can be said in way of treatment, and all experiments in this line must be wholly empirical. As stated above, we do not know

the first or æcidio-stage of the fungus, and it is not certain that this stage is necessary for its continued propagation. The parasite is endophytic, or grows within the tissues of the leaves of the host plants, and by the time it has become visible on them by its production of spores, the body of the fungus has already attained considerable growth and is beyond the reach of fungicides. We can only hope to keep the disease off the trees by preventive applications, and in localities where some treatment seems to be imperative we suggest spraying the foliage with some of the sulphate of copper solutions, eau celeste for example, as being most likely to be protective. Very dilute solutions of chloride of iron may also protect the trees from the attacks of this parasite.

(*e*) BIBLIOGRAPHY.

Winter: Rabenhorst's Kryptogamen Flora (Pilze); I; p. 193.
Sorauer: Pflanzenkrankheiten; Zweite Auflage, II; p. 226.
Trelease: Preliminary List of the Parasitic Fungi of Wisconsin.
Peck: Report XXV, 1873; p. 116.
Arthur: Bulletin of Iowa Agricultural College, November, 1887; p. 159.
Burrill: Parasitic Fungi of Illinois; I. Uredineæ; p. 177.
Frank: Die Krankheiten der Pflanzen; II; p. 486.
Grevillea: Uromyces prunorum; Vol. VII; p. 12.
——— Puccinia prunorum: Vol. III; p. 54.
——— Uromyces prunorum var. amygdali; Vol. II; p. 19.
Fuckel: Symb.; p. 50.
Halsted, B. D.; Bull. Iowa Agri. College, 1888.

6.—Cotton-leaf Blight.

Cercospora gossypina, Cke.

(Plate IV.)

(*a*) GENERAL OBSERVATIONS, DISTRIBUTION, ETC.

The disease here named Cotton-leaf Blight is quite distinct from the dreaded "Cotton Rust" that so often has blasted the hopes of the planters, and, in comparison, is of little consequence. Anything, however, which may affect a crop of such vast importance, even though slightly, deserves consideration.

A number of fungi are known to infest the living cotton plant, but, so far as we have observed, the one most conspicuous from the effects produced is *Cercospora gossypina*, Cke. This fungus was first described by Professor Cooke in Grevillea, Vol. XII (September, 1883), page 31, from specimens collected in South Carolina and distributed by Ravenel.* Excepting that it has been occasionally confused with the true Cotton Rust, we do not know that it has received any attention from popular writers. Ravenel knew of its occurrence in South Carolina, Georgia, and Florida. The writer has observed it in North Carolina and Texas, so that the disease is likely to occur throughout the cotton-growing States.

In a field the disease first appears at points where the soil is damp or poorly drained, and the lowermost leaves are generally the first to be attacked. Frequent showers or heavy rains are favorable to the spread of the malady, and at the time of picking, one will often find all the leaves on many plants more or less affected.

* Rav. Amer. Fungi, No. 583.

The fungus begins its attacks as soon as the first leaves are fairly formed, and from that time until the close of the season it continues its depredations. Our observations have not been sufficiently numerous or complete enough to enable us to make any definite statements as to the actual injury occasioned by the blight. The vitality and assimilating powers of the diseased leaves are more or less affected, according to the virulence of the attack, and in severe cases a seriously diminished crop must necessarily be the result.

(*b*) EXTERNAL CHARACTERS.

If the lower leaves are carefully examined about the time the plants are beginning to bloom, one will see, here and there, some of them marked with reddish-brown spots, irregular in outline, and variously scattered over the leaf surface. The single spots vary from 1^{mm} to 4^{mm} in diameter, but often several of these run together, producing discolored patches of considerable size. The spots are visible on both surfaces of the leaves, showing that the tissues through their entire thickness are affected. In a short time the tissues within the spots die and turn brown, leaving a dark red, well-marked border between the dead and the surrounding healthy tissues. The dead centers of the spots become brittle and are easily broken out, so that the leaves are often seen full of holes, or more or less ragged and torn about their margins. Leaves badly affected soon lose their lively green color, turning to a pale, sickly yellow, and finally wither and fall from the stalks.

(*c*) BOTANICAL CHARACTERS OF THE FUNGUS.

The *Cercospora gossypina* which causes the blight is a fungus botanically related to the fungus of the Strawberry-leaf Blight, but while we are now acquainted with the several stages in the development of the latter (see p. 339), we know only one stage in the former—the *Cercospora* stage—corresponding to the *Ramularia* stage in *Sphœrella fragariœ*.

It is the vegetative portion or plant body of the fungus, growing within the tissues of the leaves which occasions the destruction of the cells in the latter, producing the external changes noted above. After a while there issues from the mycelial threads within, usually coming out through the stomata, short, irregular, dark-colored branches, upon whose tips the slender, tapering, colorless spores are borne. These branches generally issue in tufts or fascicles of three or four or more, and the number of spores borne on each varies from one to several. The length of the branches as well as that of the spores varies greatly, and the number of septa or cross-walls in the latter is also variable.*

As already intimated, the more advanced stages in the life history of this *Cercospora* are unknown, but it doubtless produces spermogonial and ascosporous forms on the affected leaves after they have fallen to the ground.

What applications or treatments may serve to check or prevent the Cotton blight remain to be determined by experiment. It may

* The characters of the species as given by Cooke are as follows: *Epiphylla. Maculis effusis, indeterminatis, fuscis. Hyphis subfasciculatis, elongatis, flexuosis, fuscis* (.12^{mm}–.15^{mm}). *Sporis elongatis, superne attenuatis, flexuosis, 5–7 septatis, hyalinis* (.07^{mm}–.1^{mm} × .003^{mm}).

not be practical, or, rather, it may not pay to attempt any treatment unless the disease should become more injurious than it appears to be at present.

7.—Anthracnose* of the raspberry and blackberry.

Glœosporium venetum, Speg.

(Plate V.)

(a) History of the fungus.

In the *Agricultural Review* for November, 1882, Prof. T. J. Burrill, of Champaign, Ill., published an account of this fungus under the name of the "Raspberry Cane Rust." This is, so far as we are aware, the only publication relative to the subject. Professor Burrill did not name the fungus but merely referred to it as the "Raspberry Cane Rust," the popular name by which it is generally known, stating, however, that the parasite probably belonged to the same group as the fungus that caused the disease of the grapes known as Anthracnose. During the past two years numerous complaints of the serious injury caused by this fungus have been received by the Section from Illinois, New Jersey, Texas, Wisconsin, and Missouri, indicating that the disease is wide-spread and destructive.

The first time the disease was observed in Missouri was in May, 1887, in the horticultural grounds of the Missouri Agricultural College, and later in the season in various parts of the State. On June 7, a raspberry plantation of 250 acres, located in the southern part of the State, was visited, and it was found that nearly all of the Black-caps were suffering from the attacks of the parasite. Other plantations in the southwestern part of the State were examined, and in all cases the Black-cap raspberries were attacked. The owners, in many instances, were ignorant of the cause of the trouble; some thought that the injury was due to insects, while others attributed it to "sun scald." From information received from the fruit-growing region of Illinois, it is evident that the parasite caused considerable injury in that State. In a letter dated June 20, 1887, Mr. F. S. Earle says "that the 'Raspberry Cane Rust' is seriously injuring Black-cap raspberries and the thornless varieties of blackberries in southern Illinois."

An instance is given by Professor Burrill* of a blackberry plantation that yielded a profit of $400 a year which was so reduced in one year by the disease that it scarcely paid expenses the year following. From a careful examination of the raspberry plantations in southern Missouri the past season, the apparent injury to Black-caps is estimated to be from 10 to 12 per cent. of the entire crop. In some sections the injury is much greater than in others; but we believe this is a fair estimate of the general loss.

In November, 1887, Messrs. Ellis and Everhart described the fungus under consideration and, believing it to be a new species, named it *Glœosporium necator*.† These authors state that the fungus was re-

---

* This name is proposed for the disease caused by this *Glœosporium* in uniformity with anthracnose of the vine caused by another species of the same genus.

*Agricultural Review.

† Journal of Mycology, III, 129. *Glœosporium necator*, E. and E. On living canes of black and red raspberry. Sent from Evanston, Ill., by Charles Wheeler, August, 1881, and from Cobden, Ill., by F. S. Earle, June, 1884; also received from Columbia, Mo., June, 1887, from B. T. Galloway. Spots caulicolous pale, with a slightly raised

ceived by them from Evanston, Ill., in August, 1881, and from Cobden in June, 1884, and again from Columbia, Mo., in June, 1887. They add that *Glœosporium venetum*, Sacc., a European species found on *Rubus*, has spores of about the same size as their *G. necator*, but the former occurs on the leaves of the host, while the American fungus is found on the canes.

We have no specimens for comparison, but the description given by M. Spegazzini of *Glœosporium venetum*, published in 1877,* applies perfectly to the American fungus described by Ellis and Everhart in everything excepting that it is said to occur on the leaves.

In the description of *G. necator* reference is only made to its occurrence on the canes; the fact of its being very common on the leaves was apparently unknown to the authors of the species. Recent observations have led to the discovery that no part of the plant above ground is free from the attacks of the parasite. It is occasionally seen attacking the fruit, and the petioles and veins of the leaves are often greatly disfigured by it.

(*b*) EXTERNAL CHARACTERS OF THE DISEASE (Fig. 1).

That the disease is directly due to the action of the fungus, which is a true parasite, there can be no question.

On the canes.—The fungus attacks both fruiting and non-fruiting canes or suckers. On the latter it usually appears first near the base, producing small purple spots that are variously scattered around the cane. The spots first formed rapidly increase in size, and as the fungus develops the center of each becomes grayish-white in color. Surrounding each spot is a slightly-raised, dark purple border, separating the healthy from the diseased tissues. The course of development is from the lower portion of the canes upwards, so that at any time during the growing season the tip of the cane shows only the minute purple spots or early manifestations of the disease, while towards its base are found the older and larger spots. In an advanced stage of the disease the spots coalesce or run together, and appear as irregular blotches, which are frequently an inch and a half long, and sometimes completely encircle the cane. The direct damage to the tissues rarely extends to the pith; the greatest injury is confined to the cambium layer, or the portion through which the sap is conveyed in the process of growth. Thus, nearly the same effect is produced on the cane by the action of the fungus as would result to a living tree if girdled by the knife or ax. The living tissues of the

dark border, two to three millimeters in diameter, orbicular or elliptical; spores oblong-elliptical, 5–7μ by 3μ, oozing out in an amber-colored mass through a single opening in the center of each spot. Reported as being very injurious. *G. venetum*, Sacc., has spores of about the same size but is a folicolous species. The Illinois specimens were reported as *Phyllosticta necator*, but the fungus is evidently a *Glœosporium*.

* *G. Venetum* Spez. Spots marginate, without definite shape, large or small, and elevated in the center, honey or ocher yellow, surrounded by a dark purple border. Acervuli minute, prominent, gregarious, or solitary, dark; condidia oblong-elliptical 7–8 by 2½; granulose or nucleated, hyaline. In languishing leaves of *Rubus Chamœneorus*. Belluno and Coneg. liano, Italy. Saccardo, Sylloge Fungorum, Vol.—, p. 706.

There appears to be no good reason why a new name should be given our American form. The specific character of many of the imperfect fungi, of which this is one, are too often based upon characters that rarely remained fixed, and it is useless to multiply names which only lead to confusion. Therefore, Spegazzini's name *Glœosporium venetum*, being the earlier one published, is here adopted.

cane are prevented from properly performing their work, and as a result the canes become sickly; the leaves do not attain more than half their normal size, and if fruit is formed at all it never reaches its full development, but ripens prematurely or simply dries up and is worthless. If the young canes are not killed the first year the continued action of the fungus on the leaves and branches prevents the formation of fruit the succeeding year.

On the petioles and veins of the leaves.—Soon after the appearance of the fungus on the canes the petioles of the oldest leaves are also attacked. There appears near the base of the petiole the purplish spots which always mark the first development of the fungus. These are similar in appearance to those on the canes already described. Gradually the disease spreads along the petiole toward the leaf, and soon the frame-work of the latter shows the whitish, blister-like spots.

The parasite usually confines its attacks to one side of the petioles and veins, which results in an unequal development, the leaves become distorted, and their edges rolled inwards towards the midrib. Frequently the pedicels of the fruit are attacked, and this is usually followed by the complete drying up of all the berries.

On the parenchyma of the leaves.—The fungus produces spots on the leaves similar to those on the canes, excepting that they are much smaller (scarcely exceeding 1^{mm} in diameter) and more closely approximated, but rarely coalescing. The injury extends through the entire thickness of the leaf, and frequently the diseased tissue separates from the surrounding healthy part and the leaf becomes riddled with holes.

(c) BOTANICAL CHARACTERS OF THE FUNGUS.

About 60 species of the genus (*Glœosporium*) to which the fungus of Anthracnose of the raspberry and blackberry belongs are known to occur in the United States. They are all true parasites, but very little is known respecting their development. The species attacking the raspberry and blackberry consists of three parts, namely, (1) the mycelium or body of the fungus, composed of very slender, colorless threads ; (2) slender stalks, called basidia, and (3) reproductive bodies, called spores, that are borne upon the tips of the basidia.

The mycelium creeps between the cells of the host and obtains its nourishment at the expense of the latter. As a first result there is simply a slight discoloration of the cell contents ; later the cells lose their shape, and very soon they collapse entirely, leaving nothing but a mass of dead and dry tissue. Just as far as the fungus threads extend the tissues of the host are destroyed (Fig. 2). As already stated, the injury rarely reaches to the pith ; for the most part it is confined to the bark and cambium layer. Near the center of the diseased spot the ends of many of the creeping threads unite and form a dense tuft, which, as seen under the microscope, resembles a mass of short, slender, club-shaped bodies ranged side by side. These bodies are the basidia ; they are formed beneath the cuticle, which they soon rupture, and appear on the surface in the form of a minute globule, being covered with a clear gelatinous substance.

Upon the tips of the basidia the spores are borne (Fig. 2, *a*) ; these are colorless, oval or oblong, and very minute one-celled bodies. Each basidium develops but a single spore, and the entire mass of spores and basidia are held together in the gelatinous substance, which, however, readily dissolves in water.

If the diseased spots are examined after a week or ten days of dry weather an abundance of the minute globules above referred to will be seen. If a rain follows, the substance which cements the spores together is quickly dissolved and the latter are set free. A microscopic examination of the drops of water which collect on the canes and leaves after a rain will show numerous spores floating about, and many will be seen to have germinated by sending out delicate colorless filaments or germ tubes.

Spores (Fig. 3) sown in a drop of water germinate at the expiration of about twenty-four hours, so that if the water which sets the spores free evaporates shortly after the gummy substance is dissolved, the former are in such condition that the slightest breath of air is sufficient to carry them from place to place. If they fall upon healthy leaves or canes, and the proper conditions of moisture and heat are present, they will germinate, and it is very probable that the slender filaments produced will penetrate the cuticle of the plant and ultimately produce new diseased spots and give rise to the same fungus development from which they were derived.

Early in June of the present year (1887) numerous sowings of the spores were made in various solutions prepared by macerating the green and ripe fruit in water, and juices made in a similar manner from the leaves and young canes were also used. It was found that spores sown in pure water germinated much more readily than any sown in the solutions. It was also discovered that if the spores which had germinated in pure water were removed to the prepared solutions, the filaments therefrom grew with greater vigor than when left in pure water. From these experiments it would seem reasonable to believe that pure water is required, if not absolutely necessary, for the germinations of the spores, and that the germinating filaments, after they have entered the tissue, find in the juices of the plant all that is necessary for their future development. Another fact which would further warrant us in this belief is that the disease rarely spreads during dry weather. It spreads rapidly, however, during damp weather and at times when moisture collects in drops on the canes. Although no new spots are formed during a dry season the old spots continue to enlarge, and frequently the leaves wilt, owing, no doubt, to the fact that the injured cane can not supply the necessary amount of moisture. It is not known how long the mycelium is capable of retaining its vitality; nor do we know of any other mode of propagation excepting by the spores above described. Possibly the fungus lives in the old canes through the winter, and is capable of developing a new series of spores the following spring. This may or may not be the case. One fact, however, in this connection is worthy of note, and that is, that spores taken from old spots after the canes have been kept for several months in an herbarium will germinate.

The fungus under discussion is only known in its active or injurious form; other stages may occur, but they have never been satisfactorily made out. A *Phoma* which develops an immense number of minute, oval, colorless spores is frequently found on the old spots made by the *Glœosporium*. In this *Phoma* the spores are produced within minute dark-colored sacs, called pycnidia, which appear to the naked eye as minute black specks. Another fungus, very similar to the above, but which should be referred to the genus *Phyllosticta*, has been found associated with the *Glœosporium*, but whether either

of the above are in any way genetically related to the latter has never been demonstrated.

(*d*) TREATMENT.

As a means of preventing Anthracnose of the raspberry we suggest that the plants be trained and pruned in such manner that plenty of air and sunlight will at all times be permitted to come in contact with the canes. By far the most vigorous plantations that have come under our observation were those in which the rows were 6 feet apart and the plants were 5 feet apart in the row. Cultivation was made both ways and by careful pruning the plants had been made to assume a close, compact form.

In no case should the canes that have been killed by the fungus be permitted to remain in the field, as all the evidence at hand indicates that the disease first appears where such canes have been left standing. We have in mind a small raspberry plantation in which the disease was first noticed near the center of the field among the plants of the Souhegan variety. The plants in question had been neglected for two or three years, and as a result the canes were long and straggling and many of them were dead. As a further detriment to their growth the suckers had grown up so thickly about the lower part of the plants that they were completely choked. On these plants the disease first appeared, but soon spread to adjoining rows which had received better treatment. Upon an examination of the canes where the disease was first observed the old scars made by the fungus the previous year were found, showing that the disease had been present for several years but had escaped detection.

Sulphate of iron has been used with success in combating the Anthracnose of the grape, and it is reasonable to suppose that, if used properly, it will prove an effective remedy against the very similar disease of the blackberry and raspberry. Prepare a solution by dissolving 2 pounds sulphate of iron in 5 gallons of water, and, by any convenient method, apply to the shoots before the buds have started in the spring. Later, if there be any signs of the disease, the use of the Bordeaux mixture is recommended.

8.—Anthracnose of the Bean.

Glœosporium lindemuthianum.

(Plate VI.)

(*a*) GENERAL OBSERVATIONS.

Wax or butter beans, those having yellow pods, are subject to the attacks of a fungus parasite producing a disease which may be named Anthracnose of the bean. It is sometimes called "rust," but that term should be restricted to a disease resulting from another cause.

The disease has been known to gardeners a long time, but its botanical nature has not been studied until quite lately. It was first named by Saccardo and Magnus, and has since been studied (1883) by Frank.*

*An account of this disease, with a figure illustrating its character, by Prof. William Trelease, was published in the *Cultivator and Country Gentleman*, October, 1885.

It occurs in Germany, France, Italy, England, and the United States. In the latter country it seems to be very generally distributed, as specimens have been sent to the Department from Maine, Massachusetts, Wisconsin, Pennsylvania, Louisiana, and the District of Columbia. An allied species, *G. leguminis*, is also found in California, upon a different host, however.

It is the pods and the beans they contain that are chiefly affected, the other parts of the plants being rarely if ever attacked. Frank attempted to infect the leaves and stems, but with no result. He also tried to infect different plants, but failed in this also. In this country, however, the disease attacks water-melon rinds as well as beans.

(*b*) EXTERNAL CHARACTERS.

The disease makes its appearance as a small, reddish-brown spot which grows rapidly, soon becoming black in the center. With the exception of a narrow line on its circumference this black center afterwards turns to a dirty gray or light brown.

The spots are usually round, from 2^{mm} to 6^{mm} in diameter, the largest rarely exceeding a centimeter.

They are composed of a reddish-brown band on the outside, followed within (in most cases) by a narrow black band, and have a brownish or dirty white center, over which is a mass of light-colored powder. The spots may grow until they extend entirely across the pod, and several sometimes coalesce, forming large brown patches that nearly cover its surface (Fig. 1). From the first, these spots are sunken below the surface of the healthy tissue, and as the disease progresses they sink deeper and the pod becomes more and more shrunken, while the bean within may also become diseased and shriveled until it has but a small fraction of its normal size (Fig. 3, *b*).

(*c*) CONDITIONS FAVORING THE DISEASE.

The young fruit is most subject to attack, and if the parasite gains a footing in the partly-grown pods, it is, of course, very disastrous, as the growth of the bean is checked, even when the latter is not diseased. It will readily be seen that the parasite, if at all prevalent, is a very injurious one to the crop; and as a matter of fact this is often the case where the conditions are favorable to the fungus. These conditions are simply dampness of soil and atmosphere, which, although favorable to nearly all parasitic fungi, seem to be more necessary to the development of this particular disease than it does in the majority of cases, and an airy, dry situation for the plants is the best means of preventing an attack.

(*d*) BOTANICAL CHARACTERS.

As found upon the bean pod the mature fungus consists of a mycelium, which penetrates the tissue of the pod and bean, sending basidia to the surface, which in turn bear numerous spores.

In general the mycelium is colored, but portions may be uncolored, even where the remainder is quite dark. It is branching, septate, of variable diameter, and contains granular protoplasm and large oil drops (Fig. 4, *b*).

The basidia (Fig. 4, *c*) are colorless and straight, with bluntly-rounded tips, and are borne in clusters.

The spores (Fig. 4, *e*, and Fig. 5) are about twice as long as broad, nearly cylindrical, rounded at each end, contents granular and without nuclei. They sometimes project from the clusters of basidia in compact masses, held together by some substance which dissolves at once upon coming in contact with water.

Mingled with and surrounding the clusters of basidia are a few large dark-brown hyphæ (Fig. 4, *d*), closely resembling the filaments of *Vermicularia*. They are much larger and longer than the basidia of the *Glœosporium*, are septate, and sometimes have a bulbous swelling at the level of the tops of the basidia; below this point they are colorless. Sometimes the whole hypha is uncolored, but in this case it is usually smaller, indicating that it is not mature. They are few in number as compared with the basidia, a dozen being a large number for one cluster or pustule. These hyphæ are not mentioned in any published account, but they were constant in the specimens examined, although very scarce in some cases. The specimens were from the States previously mentioned and from Germany, and were named by Ellis, Farlow, and Trelease. They were also present in the same fungus on water-melon rind.

Life history.—The spores falling upon the surface of the bean pod, send out a protuberance or germ tube on one side which presses close against the epidermis, and becomes transformed into a round, flattened body with a thick violet membrane. From this there soon protrudes a colorless hypha that bores through the outer wall of the epidermal cells and grows within them into a convoluted mycelium which fills their cavities* and extends rapidly downwards and laterally.

In its healthy state the bean pod is composed of two well-marked layers of tissue with a line between. The outer (exocarp, Fig. 2, *b*) is the firmer and more compact, and is generally of about the same thickness throughout the pod. The inner (endocarp, Fig. 2, *c*) is composed of larger and thinner walled cells, and is not continuous. If the beans are fully developed it is quite absent along their length, and very thin even in the intervals between them; but if the beans are not well-grown it is very thick, and in the intervals may fill all the space within the outer layer. It is accordingly thick in pods where the fungus has checked the growth of the bean.

After leaving the epidermal cells the mycelium penetrates the walls of the cells beneath it, their contents and walls almost immediately become discolored, and in the exocarp the cells collapse, forming an almost solid mass of cell walls and mycelium (Fig. 2, *a*). In the endocarp the cells do not collapse at once, but the mycelium grows in them luxuriantly, almost filling their cavities; from here it penetrates to the bean itself, and may even form spores and basidia between the testa and embryo.

The exocarp shrinks into a mere line and sometimes separates from the endocarp like the skin of a blister. Usually, however, the two layers remain connected, and the whole spot sinks in (Figs. 2 and 3).

The mycelium that is in the epidermal cells in the center of the spot soon forms basidia which rupture the epidermis at points, forming pustules (Fig. 4); these pustules are so numerous in the older spots that they coalesce and are lost sight of, so that the surface is nearly or quite covered with a mass of basidia. The pustules are just visible to the naked eye, and sometimes have a dark-brown color,

*Sorauer, Pflanzenkrankheiten.

owing to the brown hyphæ among the spores. It is from them that the spore masses already spoken of project. They occur only over the light center of the spot, the black line forming their limit; in fact, the light color is probably caused by the spores and ruptured epidermis.

The presence of the large dark-colored hyphæ raises a question of classification. These hyphæ are not mentioned in any description of *Glœosporium*, and, so far as is known, are not present in any other species of that genus, but are, on the contrary, characteristic of the genera *Vermicularia* and *Colletotrichium*. The appearance and structure of the bean fungus accords perfectly with the description of *Colletotrichium*, even to the location of the brown hyphæ (setæ) about the circumference of the pustule, and if the setæ are an organic part of the bean fungus it seems probable that the name must be changed from *Glœosporium* to *Colletotrichium*.*

(*e*) TREATMENT.

So far as possible plant in a dry and airy situation in light soil. Sulphur has been used and is reported to check the disease somewhat, but is not a sure protection. Under some circumstances applications may be made of solutions of sulphate of iron or copper, but the use of these compounds on this fruit can not be generally recommended owing to their poisonous character. Experiments might be made with liver of sulphur, 1 ounce to 5 gallons of water. The action of this fungicide is immediate, and it may be freely used without danger to health.

9.—LEAF-SPOT DISEASE OF CATALPA.

(Plate VII.)

(*a*) GENERAL OBSERVATIONS.

The foliage of a number of our ornamental shade trees is sometimes seriously disfigured or caused to fall prematurely by the attacks of parasitic fungi. A notable example of this is the case of the catalpa (*C. bignonioides*), some trees of which, growing on grounds near the Department buildings, have had their leaves more or less injured from this cause for several seasons past. The work of the fungus is manifest by round, brown spots upon the leaves which appear early in June, and in some few instances the ravages of the parasite have been so severe as to nearly defoliate certain trees by the end of July or early in August.

The geographical limits of the disease are not known, but it is evidently quite extended, as samples of the affected leaves have been observed in widely separated localities.

(*b*) EXTERNAL CHARACTERS.

So far as we know the attacks of the the parasite are confined to the leaves, where it produces the brown spots mentioned above. These spots are round, varying from 3^{mm} to 6^{mm} in diameter, and

* Dr. O. Penzig, in Ann. d. Agria., 1887 (Studi Botanici Sugli Agrumi e Sulle Piante Affini). Pl. XXXVIII, Figs. 3 and 4, p. 384, has figured and described *Colletotrichium glœosporioides*, and so far as can be judged from the illustrations, the fungus has every generic characteristic of that upon the Bean. In his Funghi Agrumicoli, 1882, p. 66, Fig. 90, Penzig described the same fungus as *Vermicularia glœosporioides*.

they occur indifferently on any part of the leaf, often running together, forming large brown patches, and in severe cases they occupy the greater part of its surface, seriously interfering with the process of assimilation. They are caused by the growth of the parasite within the tissues, whose limited development causes the sharply-defined, rounded outline of the spots. The tissues are destroyed through the entire thickness of the leaf, and this portion often breaks away completely from the surrounding healthy parts, leaving the leaf full of round holes. Fungi producing this effect are sometimes named "shot-hole fungi." In advanced stages of the disease the leaves become wrinkled and deformed; finally, losing all vitality, fall to the ground.

(c) MICROSCOPICAL CHARACTERS.

A section through one of the spots where it joins the healthy tissue shows a well-defined boundary in the tissues by a peculiar transformation of the cells. In the yellowish-green border by which most of the spots are surrounded the different leaf tissues become a homogeneous mass of parenchyma; within this the tissues are so shrunken and altered that the cells have lost all definiteness of form and contents, forming a brown and disorganized mass (Fig. 1, *b*).

This disease appeared to be sufficiently important to demand further investigation, and some time was occupied in this work.

Several different fungi were found on the dead spots, those worthy of note being *Macrosporium catalpæ* and *Phyllosticta catalpæ*. Both these species are described by mycologists as forming spots; both were observed on the same spot, and the mycelium of both was found penetrating the tissues.

The *Macrosporium* is the more abundant of the two, being generally constant on both sides of the leaf, excepting on the very young spots. Its growth sometimes extends beyond the limits of the latter to the green tissues immediately surrounding them. The conidiophores, or spore-bearing stalks of this fungus, are reddish-brown; they occur singly or in groups, and on the under side of the leaf they were frequently seen emerging from the breathing pores or stomata (Fig. 2). The spores (Fig, 2, *b*, and 3) are compound or made up of a number of cells, each cell or division being capable of ready germination (Fig. 3). The mycelium produced by germination is comparatively large, colorless, frequently divided by septa, and its growth is readily carried on in a variety of media.

The sowing of fresh spores on healthy leaf surfaces, an experiment frequently tried, led to no positive results.

The species of *Macrosporium* are so frequent on dead vegetable substances and so rarely, if ever, found alone on living tissues that they are generally believed purely saprophytic in their habits and incapable of producing direct injury to living plants. If this be universally true, then we must look to the other fungus mentioned as the cause of the leaf-spot disease under discussion.

The *Phyllosticta*, many species of which are known to produce leaf-spot diseases in other plants, found on the spots on the Catalpa leaves is doubtless the cause of them. Its mycelium is very delicate, being much finer than that of the *Macrosporium*, so that it is very difficult to see it in diseased substance of the spots, even by the most careful manipulation. The spores of this fungus (Fig. 5) are formed within minute black conceptacles or pycnidia (Fig. 4), that are developed just beneath the cuticle of the leaf which their growth

finally ruptures. These conceptacles are visible to the naked eye, appearing as very minute black points on the surface of the spots. They are not abundant, and often there are many spots, called sterile, entirely without them. The spores are difficult of artificial germination, and no results were attained by sowing them upon healthy leaves.

Possibly there is some genetic connection between the *Macrosporium* and the *Phyllosticta*. This has been suggested as a probability, but the studies we were able to make afforded us no opportunity to form even an opinion on this question.

Where a few trees of catalpa are grown especially for shade or ornament it may be possible to preserve their foliage from this disease by the application (preventive) of some fungicide, but no experiments have yet been made with this end in view.

10.—Black-spot on Rose leaves.

Actinonema rosæ.

(Plates VIII and IX.)

(a) GENERAL OBSERVATIONS.

There are several parasitic fungi that produce black spots upon the leaves of our cultivated roses; but the most common and injurious, and the one to which we generally refer in speaking of the "leaf spot," is that known to mycologists as *Actinonema rosæ*. It was named *Asteroma rosæ* by Libert as early as 1826, and afterwards transferred to the genus *Actinonema* by Fries. It is also called *Asteroma radiosum*. The nature of the disease has been studied and described by Frank and Eriksson, and Sorauer describes it in detail in the second edition of his work on "Diseases of Plants."

The disease is very wide-spread, occurring in nearly all the countries of Europe as well as in the United States. Here it is quite universal, although there are local areas apparently free from it.

(b) EXTERNAL CHARACTERS.

Late in the spring, or early in the summer, the disease makes its appearance in the form of round or irregularly-shaped black spots upon the upper surface of the living leaves. Generally only the full-grown leaves are attacked, and those within three or four inches of the branches seem to be healthy.

The spots are small at first, but as the disease progresses they increase in size, and may become half an inch in diameter. Often a number of them coalesce, and in severe attacks the leaf is nearly covered with large dark patches.

From the beginning the spots are fringed at the edges, and although the form is frequently irregular at first, they usually become distinctly circular later, especially on the smooth-leaved varieties. In the latter part of the season the spots grow light colored and dry in the center, showing that that part of the leaf is entirely dead, and by this time, if not before, the discoloration penetrates through the leaf and appears on its under side.

The moss roses and those with thick rough leaves, seem to suffer more than other kinds, but there are few, if any, that are invulner-

able to the parasite. Those which escape early in the season are apt to succumb before fall if the other roses in the vicinity are diseased.

The effect of the disease upon the leaf is soon apparent by its turning yellow in places, and sometimes by a yellow band outside the black spot. When cold weather approaches the leaves that are diseased are the first to turn yellow. During the autumn the yellow color is apt to appear at the apex of the leaflets, whence it spreads downward and is succeeded by brown. A leaf with a green base and brown tip with a yellow band between is very characteristic of this disease. Premature fall of the leaves is another effect of this parasite. Diseased leaves may fall before they turn yellow, and plants attacked by the fungus generally have a partly defoliated appearance.

It is evident that we have here a case in which the effect of the fungus is not confined to the area it actually occupies. Its growth does not extend over all those parts of the leaf which turn yellow, nor can any mycelium be found at the base of the petiole when the leaf falls before its time. It seems that the interference with assimilation which must result over the diseased areas so affects the entire leaf as to destroy its vitality. If the autumn is long and pleasant the plant is apt to exhaust itself by putting out new leaves, which are destroyed by frost before they can be of any service.

The fungus is very hardy and does not depend to any great extent upon climatic conditions for its development, but like other diseases of this kind it proves most troublesome in a moist and warm environment.

Roses kept under cover are better protected from infection, and are consequently more free from the disease. This explains why tea roses and others that are kept in greenhouses over winter are not so badly affected as those in open grounds. The truth is, probably, that the disease has a long period of incubation before it is visible, and before this period is over for roses that have been potted the season is far advanced and they do not have time to get badly diseased before they are potted again.

(c) BOTANICAL CHARACTERS.

The parasite, as it is known on the rose, is probably but one stage in the life history of the fungus. From its analogies it is classed with the sphæriaceous fungi, although so far as recorded no perithecia have been observed in this species. But in other species similar in habit to this one, perithecia-like forms, more accurately known as pycnidia, occur.

Mycelium.—The mycelium is composed of two distinct parts, one situated between the cuticle and epidermis (Plate IX, Fig. 2, *b*), and the other penetrating the leaf tissues. The former is apparently superficial (Plate VIII, Fig. 2), as it shows through the transparent cuticle. It is composed of branched septate hyphæ that radiate from a center and lie side by side in strands of from one to eight (Plate VIII, Figs. 2 and 3). When a hypha branches it may run along parallel to the main thread or may bend off at an acute angle and form an independent strand (Plate VIII, Fig. 3). Other mycelial filaments branch off from the under surface of this superficial layer and penetrate the leaf tissues, first entering the epidermal cells and sometimes nearly filling them with convolutions (Plate IX, Fig. 2). From these it pushes between the palisade cells, and finally appears

in the loose parenchyma (Fig. 3). Below the epidermal cells it is rarely visible, since it is so transparent that it is easily concealed by the cell contents ; but when the cells are dead and shrunken it can be seen between them (Fig. 3). It penetrates the tissues very slowly, and reaches the loose parenchyma only in the last stages of the disease. This second portion of the mycelium absorbs nourishment for the entire fungus.

Spores.—The spores are borne upon the superficial layer. Short vertical branches may arise upon any of the strands ; these branches force the cuticle apart from the epidermis and soon form colorless two-celled spores upon very short basidia. When the spores are nearly full-grown the pressure upon the cuticle becomes great enough to rupture it irregularly (Plate IX, Fig. 2, *b*), allowing the spores to escape (Plate IX, Fig. 2). The mature spore is deeply constricted at the union of the two cells. The cells are oblong, nearly twice as long as broad, sometimes larger at the ends than in the center, and contain two nuclei. Sometimes the two cells fall apart; and before they become free from their basidia, the lower one frequently has the appearance of a pedicel (Fig. 4).

The effect of the parasite upon the leaf tissues is at first apparent in the shape of a dark yellow mass, evidently composed of the transformed cell contents that collect in the upper part of the epidermal cells. The upper row of palisade cells next become discolored, and the chlorophyll bodies disorganized, and this process slowly extends through the leaf. It is this discoloration of the cell contents that gives the dark color to the spot. In some species of *Actinonema* the mycelium itself is dark colored ; but on the rose it has little or no color, and the fringed appearance of the spots is due to the fact that a few discolored cells follow the mycelium where single strands project beyond the others. Just underneath the fruiting spots the mycelium seems to have some color (Fig. 2, *d*), and these spots look blacker than the surrounding surface.

(*d*) TREATMENT.

Owing to the hardy nature of the fungus and to the fact that the mycelium develops within the leaf tissues, the disease is very difficult to deal with. Although the fungus does not live over winter in the woody portions of the plant, the disease, having once entered a garden, is sure to re-appear for successive seasons, for the spores are lodged upon the buds at the bases of the petioles by water trickling down the leaf-stalk, and the shoot springing from these the following season is necessarily tainted. For the same reason cuttings from diseased bushes will spread the fungus. Unless some plan can be adopted by which the spores can be destroyed early in the season, before they have germinated and produced a mycelium within the leaves, a garden once infested by the parasite is beyond recovery, and a new site must be selected in which no roses must be planted that are not perfectly healthy.

It is probable, however, that we may succeed in saving roses once attacked. For this purpose all the leaves should be carefully burned in the fall, and the bushes and ground carefully sprayed with some fungicide before the buds start in the spring. Much may also be done by picking and burning every leaf as soon as it shows the faintest trace of disease.

A solution of copper sulphate may be used for spraying the bushes, but should not be used upon the leaves, as it will be apt to burn the

foliage. After the leaves have started applications of Bordeaux mixture or eau celeste, modified by the addition of carbonate of soda, will be beneficial in preventing the spread of the disease. This treatment should be repeated three or four times during the season, so as to protect succeeding growths of leaves.

11.—Rose rust.

Phragmidium mucronatum, Winter.

(Plates X and IX.)

(*a*) Historical.

The rust of roses is a disease which has been known to botanists and horticulturists for nearly a century. The minute parasitic fungus causing the malady was first described by Schrank,* a European botanist, under the name of *Lycoperdon subcorticium.* Many later botanists have described it under various names.†

For a long time it was retained in the genus *Puccinia*, but Link, in 1825, placed it in the genus *Phragmidium*, where it still remains.‡

This parasite is common in Europe and is widely distributed in this country, attacking both wild and cultivated plants; in severe cases the death of the host is the result. It has recently been observed in California, by Prof. S. M. Tracy, infesting to an injurious degree hybrid perpetual roses; in one instance a Maréchal Niel, growing in a greenhouse, was very badly affected. Tea roses rarely suffer from its ravages; it is the hardy, hybrid perpetuals that suffer most.

(*b*) External characters (Plate X, Figs. 1 and 2).

Early in summer the disease first makes its appearance on the leaves, leaf petioles, or young stems in the form of variously-shaped lemon-yellow spots, which increase in size as the season advances. On the leaves the spots are scattered irregularly over both surfaces, being lighter in color above and below. These spots mark the points of development of the fungus, and as this development progresses within the tissues the parasite finally breaks through the epidermis on the under surface of the leaves, forming little granular pustules. The larger pustules appear on the principal vines, along which they may extend for a considerable distance. When the nerves are thus attacked the leaves become twisted and misshapen.

---

* Hopp's Bot. Taschb., p. 68.

† *Ascophora disciflora*, Tode, Mcke. Fung., page 16. *Aregma mucronatum*, Fries, Obs. Myc., I, page 225. *Phragmidium incrassatum* var. *rosarum*, Wallr,, Flor. Germ. Crypt., IV, page 188. *Phragmidium mucronatum*, Lk., Spec. Plant, II, page 84. *Puccinia mucronata* var. *rosæ*, Pers., Syn. Fungi, page 230. *Puccinia rosæ*, D. C., Flor. Franc., vol. 2, page 218. *Uredo rosæ*, Pers., Dispos., page 13. *Uredo miniata*, Pers., Syn., page 216. *Uredo elevata*, Schum., Enum. Plant. Sacll., II, page 229. *Uredo pinguis*, D. C., Flor. Franc., II, page 225.

‡ It appears to us that the name given this fungus by Link, *Phragmidium mucronatum*, is the one which ought to be adopted, it being the earliest name applied to this species in the genus *Phragmidium*. It is certainly straining a point, needlessly multiplying synonyms, and confusing the citations of authors to revive a part of an older name after the fungus has already been published under *Phragmidium* merely for the sake of paying tribute (doubtful in some cases at least) to him who first describes the fungus or one stage in its development.

The spots on the leaf stalks and shoots are usually larger than those on the leaves. They are elongated in the direction of growth (one-half inch sometimes), and are surrounded by the broken edges of the ruptured cuticle. The action of the parasite often incites an excessive cell development in the tissues of the host, in consequence of which the shoots are found more or less bent away from the point of attack (Fig. 1, *a*).

If we examine the rose leaves closely about mid-summer we will find that the orange-yellow spots have been replaced (to all appearances) by spots of a brick-red color, and later in the season another and more marked change occurs; the under surfaces of the diseased leaves then are seen to be more or less thickly sprinkled with minute black, hair-like tufts. Frequently the brick-red stage and the one last mentioned are found together (Fig. 2), and sometimes all three forms may be seen on the same leaf.

(c) BOTANICAL CHARACTERS.

A microscopical examination of the early or orange stage of the disease will show us that the pustules are made up of an immense number of globose or angular bodies arranged in compact vertical rows or chains (Plate X, Fig. 3). The formation of these bodies begins at a point some distance beneath the cuticle, and it is by their growth that the latter is finally ruptured. This period of development is known as the æcidio-stage of the parasite, and the angular or rounded bodies referred to are the æcidiospores. These have an average diameter of from 18μ to 22μ ($1\mu=\frac{1}{2500}$=inch), and, like the seeds of higher plants, they serve to spread and propagate the fungus. With these spores, usually surrounding each group or pustule, are peculiar club-shaped growths termed paraphyses (Fig. 3, *a a*).

In the second or uredo-stage the spores are similar in shape and size to the æcidiospores, but they have their outer surface finely roughened and they are grouped differently (Plate X, Figs. 3 and 4). Surrounding each collection of these spores the same club-shaped bodies observed in the æcidio-stage occur. These are sterile organs of doubtful function, which accompany the spores of many fungi. In the present instance they have obtuse club-shaped tips and are somewhat incurved and form a sort of cup around the spore masses.*

The spores in this second or uredo-stage are borne on short pedicels and otherwise differ from the æcidiospores in having their outer surface roughened (Fig. 4).

The spores in the third or last stage are very markedly different from those preceding. They appear, when magnified, as illustrated in Plate X, Fig. 7. A more highly magnified figure of one of these spores is shown in Plate IX, Fig. 5. They are very dark colored, roughened, cylindrical bodies, about 25μ in diameter and 60μ to 75μ long, divided by septa into from 5 to 11 cells and abruptly terminated by a short, colorless point. The stalks supporting them are comparatively short, colorless, and considerably enlarged or swollen towards the base. The same colorless paraphyses accompany this stage as were seen in the two preceding.

The æcidio and uredospores germinate readily, under favorable conditions, as soon as they reach maturity; but when kept dry for a

* The uredo-stage of this fungus has recived several names by the older mycologists, among them *Uredo miniata*, Pers., and *Coleosporium miniatum*, Lev.

few weeks they lose this power of germination. The last spores formed, however, the teleutospores, as they are called, retain their vitality for a long time and can rarely be germinated by artificial cultures until the spring following the season of their development. In the process of germination the spores of the first and second stages send out slender germ tubes which, if properly placed, penetrate the tissues of the plants attacked. These spores are evidently designed for the immediate and rapid propagation of the fungus during the growing season, while the teleutospores preserve the life of the parasite during the winter and only germinate in the spring, ultimately giving rise to the various forms we have described.

The teleutospores germinate by sending out somewhat thickened tubes (usually one tube issues from each cell) which, after attaining a length several times that of the spore, produce several minute globose bodies on short and slender stalks. These bodies, named sporidia, are easily wafted from place to place by the slightest currents of air, and when they fall upon Rose leaves where there is moisture they send out slender filaments which probably bore their way through the cuticle into the interior of the leaf, and a new fungus growth takes place.

(*d*) TREATMENT.

Understanding the character and manner of development of the Rose rust enables us to suggest several methods of combating it. In the first place the plants should be carefully watched, and at the first appearance of the disease the affected branches should be removed and destroyed. If the disease re-appears upon the new growth it would be best to dig out the plants and destroy them, as it is better to sacrifice a few plants at the beginning than have them breed infection to all others which may be near.

Never wait until the spots show the granular pustules before destroying the affected parts, but remove the shoots upon the first indication of the yellow spots. Where the disease has prevailed it would be well to rake all the old and fallen leaves together in the autumn and burn them, for by this means millions of the teleutospores will be destroyed.

It is probable that some benefit may result from the use of solutions containing sulphate of copper, as this substance is known to prevent the spores of many fungi from germinating, even when present on the parts subject to attack in very small quantities.

In localities where the disease has prevailed in previous years a preventive treatment may be made by applying to the plants in early spring, a solution of sulphate of copper and carbonate of soda, prepared as directed on page 331. This should be applied to the leaves and young branches with an atomizer, thoroughly wetting all the parts, but not drenching them with the fluid. After drying this preparation is strongly adherent, and its presence even in very minute quantities is sufficient to prevent the spores of the fungus from germinating. It is obvious that if the germination of the spores is prevented infection can not take place. A very dilute solution of chloride of iron, which is reported to have proved efficacious in the treatment of the coffee disease (*Hemileia vastatrix*), may also be tried as a preventive.

12.—THE ROSE PHRAGMIDIUM.

Phragmidium speciosum, Fries.

(a) GENERAL OBSERVATIONS.

The Rose *Phragmidium* belongs to the *Uredinicæ* or rust-producing fungi, and like the preceeding, to which it is closely related, it is a parasite of the rose, confining its attacks, however, to the stems, rarely, if ever, infesting the leaves, although it is sometimes found upon the leaf stalks. It was first described by Schweinitz, an American botanist, in 1822, under the name *Seiridium marginatum*. Later it was placed in the genus *Phragmidium* by Fries, who named it *Phragmidium speciosum*.

It is quite generally distributed throughout this country, and complaints have been received by this Section of the injury it has occasioned, one correspondent stating that his plants had been infested for four or five years, the stems attacked being invariably killed.

(b) BOTANICAL CHARACTERS.

Doubtless this species produces the same spore forms as does *Phragmidium subcorticium*, but the samples forwarded to us for investigation exhibit only the last stage or mature form. In this condition the fungus appears on the stems as illustrated in Plate IX, Fig. 6, thickly covering them with black, irregular masses, suggesting at first sight the appearance of certain species of bark-lice. A closer inspection of the cushion-like masses reveals their true nature, and a microscopical examination shows that they are really composed of a dense growth of fungus spores supported on long slender stalks. Several of these spores are represented in Fig. 7. They are brown in color, five to seven celled, with a somewhat abruptly-pointed colorless apex, and are particularly attractive objects under the microscope. In size they are about 30μ in diameter by from 70μ to 100μ in length. The supporting stalk is many times the length of the spore, slightly tinted in its upper part, but colorless below, and nearly uniform in diameter throughout.

The body of the fungus (*stroma*), from which arise the spores, does not penetrate into the woody tissue of the stem, but its growth seems to be confined to the inner bark and cambium layer, the life of which it destroys. In severe cases the stems are often completely girded by the parasite, so that the fatal results arising from its attacks are not difficult to understand.

(c) TREATMENT.

The fungus re-appears each year on the same stems, if they survive, indicating that it is perennial in habit, a fact making it all the more difficult to combat, for there seems to be no remedy that will destroy the parasite which will not be equally destructive to the host.

Heroic treatment with the knife, cutting away all the diseased stems and burying them, is all that we can now recommend. A more complete knowledge of the development and life history of the parasite may enable us to successfully combat without resorting to such severe measures.

13.—The powdery mildew of the gooseberry.*

Sphærotheca mors-uvæ, B. and C.

(Plate XI.)

(a) General remarks upon the growth and development of the powdery mildews.

The mildew that has proved so destructive to the gooseberry industry in the United States, is a member of a group of fungi known to botanists as the *Erysipheæ*. The species of this group are mainly parasitic upon higher plants, and several of them rank among the most injurious of fungi to cultivated crops. The family, according to Saccardo,† is divided into nine genera, embracing a hundred species, about half of which are found in this country.

Among the leading species preying upon cultivated plants is *Podosphæra tridactyla*, De By. This is often abundant upon the leaves and twigs of cherry, plum, and young apple trees, and does much damage in some localities. *Phyllactina suffulta*, Sacc., infests many species of forest trees, as the oak, beech, birch, ash, and catalpa. *Uncinula salicis*, Winter, is common upon willow leaves, while *U. circinata*, C and P., does much injury to the maple, especially the seedling plants. Last autumn it was difficult to find a young soft maple that did not have its leaves badly affected with this mildew. *U. spiralis*, B. and C. (*U. Americana*, Howe) is the Powdery mildew of the grape, fully treated in Bulletin No. 2, Botanical Division, pp. 18–28. Other species of the genus *Uncinula* grow upon our Virginia creeper, mulberry, linden, poplar, and elm. The large genus *Microsphæra* is well represented in the United States. The species upon the lilac, *M. alni*, Wint. (*M. Friesii*, Lev.), is perhaps the most common. It infests the birches and buck-thorn in Europe, but does not thrive there upon the lilac. Other species are found upon the honeysuckle, buttonwood, oxalis, elder, dog-wood, oaks, beeches. and other hosts. The genus *Erysiphe* is the largest in number and has a fair share of its members in this country. *E. cichoracearum*, DC., flourishes upon many compositæ, and may prove injurious to cultivated members of this great Sunflower family of plants. The most troublesome species is *E. communis*, Fr. Lev., which infests all parts of the cultivated peas, often doing much injury. Grasses are frequently attacked by members of the genus *Erysiphe*, and become coated with a whitish powdery mildew. June grass is a favorite subject for mildew. *Erysiphella* is a genus with a single known species which preys upon the flower clusters of the alder, giving them a mealy appearance.

The members of the whole family are much alike in their vegetative condition, and differ principally in the structure of their sporocarps, or cases for bearing their several spores. These mildews are all filamentous fungi that attack the host only upon its surface and give to the exterior a whitish or powdery appearance. It is on account of this prevailing mealy or flour-like coating that the common name of "Powdery mildew" has been given to the members of this group. The slender filaments of the fungus may become attached to the surface cells of the host by short irregular outgrowths

---

*By Dr. Byron D. Halsted.

†Sylloge Fungorum, Vol. I.

(haustoria) which also serve to absorb the nourishment required for the further growth of the mildew.* After the mildew has grown for a time upon the surface of the host—most usually upon the foliage—it begins to send up vertical branches from the net-work of horizontal filaments. These upright threads quickly form small oblong cells by division walls across the filament near the tip (Plate XI, Fig 1). These cells are the summer or asexual spores and are capable of germinating at once when favorable conditions are found. These conidial spores furnish a very rapid method of propagation for the mildew, and on account of their small size and powdery nature they may be carried for long distances by the wind and thus spread the parasite with startling speed.

Up to this point in the life history of the *Erysipheæ* one species is so much like that of the others that, unless something further is known, the form is not classified, or at least only provisionally. *Oïdium* is an old genus which was used to include the conidial forms of the *Erysipheæ*, and to this time this is still true in some measure. For example, *Oïdium Tuckeri* is the conidial form of a mildew which has ravaged the vineyards of Europe, but of which the final state is not known. We have a mildew of the vine which bears its sexual spores, and is classified as *Uncinula spiralis*, B. and C. It may be that this is the species which leads an incomplete existence in the European vineyards, owing to the changed conditions that there obtain. Any student of this group is quite certain to have an undetermined package of specimens that include only conidial forms. The writer has recently collected some branches from a live oak in California, the whole surface of which, dwarfed leaves included, is heavily coated with a powdery mildew, but from a lack of the whole life history the specimens remain among the unclassified.

The genera and species of the *Erysipheæ* are founded upon the sexual spores and the cases (perithecia) which bear them. The formation of these spores takes place usually after the season of most rapid growth of the mildew is closed. Two filaments unite their contents (Fig. 3) and the invigorated protoplasm begins a new form of development, in which a sac is formed consisting of a nearly spherical shell of thick walled cells (Fig. 4). In this hollow sphere are produced the spores borne within one or more sacs. To repeat, the male element of one filament fertilizes the female cell contents, and the latter produce a number of spores which are borne within a sac, and this sac (or sacs) is contained within a thick-walled body, all of which is seen as a small dark speck upon the surface of the mildewed plant. The fungus at this time is usually of a rusty brown color, instead of white and powdery as in its earlier summer condition. These sexual or perithecial spores (ascospores) do not germinate at once, but remain within the protecting covering until spring, and then begin a new series of developments and repeat the mildew of the previous season. The genera of *Erysipheæ* are founded upon the number of spore sacs (asci) within the perithecium and the character of the arms or appendages which are developed upon the spore case. There is a third form of spore which is borne in large numbers within

---

*In *Erysiphe pannosa* (*Podosphæra pannosa*, Link), the Rose mildew, *c. g.*, very thin tube-form projections appear on that side of the colorless, septate, mycelial threads which rest on the upper surface of the rose leaf, These projections bore through the outer wall of the epidermal cells, and these swell out in the interior into a bladder-shaped body. These bladder-form projections represent the complete haustorium.—SORAUER.

long, pear-shaped sacs (Fig. 2) that often accompany the perithecia, but arise without any sexual action.*

With this brief outline of the development and growth of the "powdery mildews" we may follow understandingly the life history of the gooseberry mildew, *Sphærotheca mors-uvæ*, B. and C.

(*b*) SEVERITY OF THE DISEASE.

In order that no one may doubt the destructiveness of this mildew in the United States, the following statements are quoted from the leading standard authors upon fruit culture in this country. Mr. Downing, after stating that our gooseberries come from Northern Europe, our native species not having responded rapidly to the improved condition of garden culture, and that the moist, cool climate of England is the most perfectly adapted to the growth of the gooseberry, says:†

> Under our more clear and hot sun, however, the best varieties of the English sorts do not succeed well, suffering from mildews of the fruit and foliage in nearly every locality.

Patrick Barry‡ says:

> The gooseberry suffers seriously from the mildew, owing mainly to the heat of our summers.

J. J. Thomas, § under "Mildew of the gooseberry," writes:

> This is the most serious obstacle to successful culture of the foreign gooseberry in the United States. In the cool and moist climate of England it does not exist; in the extreme northern parts of the Union it is not formidable, but on approaching the Middle States, although the bushes grow vigorously and set abundant crops of young fruit, the latter becomes covered with a thick brown or gray mildew or scurf which destroys their value.

A. S. Fuller ‖ writes of mildew:

> This is the one great enemy of the gooseberry in the United States. It not only attacks the fruit, but often extends over the whole plant, effectually checking its growth. So prevalent has this become that the foreign varieties are almost universally discarded, as there are few localities where they will succeed.

E. P. Roe ¶ says of the gooseberry:

> This native of Northern Europe and the forests of the British Islands has been developed into superb varieties which have been famous so long in England, but which we are able to grow with only partial success. It remembers its birthplace even more strongly than the currant, and the almost invariable mildew of our gardens is the sign of its homesickness.

Similar extracts might be multiplied, but those given clearly indicate the severity of the gooseberry mildew as found in this country. It not only flourishes upon our garden varieties of foreign extraction, but attacks many of our own wild species of the genus *Ribes*. The

---

*This "third form of spore, borne in large numbers within pear-shaped sacs" which are attached to the same mycelium as the conidia and perithecia, have been found in a number of species of *Erysipheæ*. From their position and seemingly evident analogy to certain sexual reproductive bodies in allied groups of fungi they have been regarded as the pycnidia, and the spores which they contain the stylospores of the fungus. De Bary has pointed out, however, that these bodies, instead of being reproductive organs of the *Erysiphe*, are in reality the fructification of a fungus which is parasitic upon it.—F. L. S.

† Fruit and Fruit Trees of America, page 499.

‡ Barry's Fruit Garden, page 477.

§ American Fruit Culturist, page 163.

‖ The Small Fruit Culturist, page 227.

¶ Success with Small Fruits, page 226.

leaves and tips of the young canes of *Ribes rotundifolia*, Michx., are usually badly infested in Iowa, and last summer the writer found the half-grown berries of a wild gooseberry in Colorado, *Ribes divaricatum* var. *irriguum*, Gray, so covered with the fungus as to preclude their perfect development.

(*c*) EXTERNAL APPEARANCE AND ACTION OF THE FUNGUS.

The mildew first makes its appearance upon the young half-grown leaves and the unfolding terminal bud of the shoot. In its early stage it has a cobweby appearance which soon becomes white and powdery from the development of the light conidial spores. Soon after this thin patches of the same character may be found upon the forming berries. Usually one side is more attacked than the other, and as the berry continues to grow it becomes one-sided or curved, because the fungus retards the development upon the infested side. If the berry is entirely covered its further development is generally checked. Later in the season the leaves, and especially their petioles and the young stems bearing them, turn to a rusty-brown color and become thickly coated with the fungus. The berries at the same time are covered with brown patches of mycelium which may be readily peeled off from the smooth skin of the fruit.

(*d*) THE SUMMER SPORES, CONIDIA.

A small portion of the mildew in its conidial stage is shown in Fig. 1. Only a few of the filaments making up the felt-like coating are represented. At intervals along these horizontal threads, branches are given off which rise vertically and soon begin a process of cross division, thus producing the conidial spores. Four of these aerial branches are shown (Fig. 1, *a*), one of which is still young, while the others are fully grown and spore-bearing. The spores (Fig. 1, *b*) as they form by this simple method of division fall from the tips of the threads and new ones continue to be formed from below. There is therefore an indefinite succession of spores from the same filament, the number depending upon the surrounding circumstances. These spores are colorless, and when produced in large numbers give the infested surface of the host a white, powdery appearance, as previously mentioned. They are borne exposed in the greatest possible degree, and may be readily scattered by the wind and in other ways. These spores quickly germinate when they fall upon a moist place on the surface of the host and produce new horizontal threads, which soon develop new vertical branches (conidiophores) with their spores.

(*e*) THE WINTER SPORES OR ASCOSPORES.

The formation of the sexual or ascospores may begin soon after the conidial spores appear, but usually they follow late in the season, and in many species (?) are not produced at all. With the gooseberry mildew they begin to form early in the life of the fungus, and by June may be found of full size. The initial stage in this formation is shown in Fig. 3, Plate XI. At a point where two of the horizontal filaments come near each other lateral branches are given off, one from each filament, One of these is slender and does not differ in appearance from the rest of the filament (Fig. 3, *a*). The other outgrowth soon becomes swollen and sometimes nearly pear-shaped

(Fig. 3, *b*). This is the female cell, the protoplasmic contents of which are fertilized by the commingling with them of the contents of the upper cell of the slender filament which is usually applied to the upper end of the female cell. The upper cell of the male organ contains a substance which corresponds in function to that within the cell coat of a pollen grain, while the female cell answers to the germ cell within the embryo sac of a young ovule. The process of fertilization in the gooseberry mildew is essentially the same as that with any ovule among flowering plants, but stripped of all the appliances seen in intricate blossoms, and therefore reduced to the simplest terms. The rapid propagation of a flowering plant by runners, suckers, bulbets, or by one or more of a long list of non-sexual methods, may be considered as homologous with the vegetative process in the mildews, including the production of the conidial spores. The latter are formed by a slow process of budding. As the result of fertilization in the young ovule there arises the seed and whatever may surround the seed or seeds, namely, the fruit. In the same manner the product of fertilization in the mildew under consideration is a "fruit" which includes the spores and their surroundings. The first evident result of fertilization in the mildew is the outward and upward growth of numerous short filaments from the base of the female cell. These threads soon completely surround the fertilized cell within and become divided by cross-walls, so that the young forming perithecium or spore case assumes the form and appearance shown in Fig. 4, Plate XI. If a section should be made through the middle of one of these nearly spherical bodies the view would show the outside cell situated upon a short stalk and occupying the center of the sphere. Later on in the development of the perithecia the outer coat becomes thicker by increase in number and size of the cells composing it, and assumes a dark chestnut color. At the same time some of the surface cells produce slender outgrowths which become as long as the diameter of the perithecium, and serve to hold it in place among the vegetative filaments of the mildew upon the surface of the infested host.

The perithecium at this stage is shown in Fig. 5, Plate XI. While these changes have been going on exteriorly the central protoplasmic contents have been shaping themselves into eight small masses, around which was formed a thick, colorless cell wall, called the spore sac or ascus. In Fig. 6 is shown a mature perithecium, the dark thick wall of which has been broken open by pressure, and the ascus is escaping from within. An ascus is shown in Fig. 7 more highly magnified and free from the perithecium.

On account of the prevailing chestnut color of the ripe perithecia the older portions of the mildew lose their white appearance and become of a dirty brown color. It is therefore easy to determine the condition of the mildew from the general appearance of the infested spot. The thick wall of the perithecium is for protection, and the spores within do not germinate until after a period of rest, during which time the surrounding covering becomes decayed or the spores escape by a rupture of its walls. The mildew passes the winter in the ascosporous condition, just as many of our annuals, like corn, etc., have their vitality concentrated within the seeds or grains that were formed by the mother plant in autumn. These winter or sexual spores find their way to the young, moist surfaces of the growing host plant during the following spring or summer, and these germinate and begin a new mildew spot.

(*f*) PYCNIDIA.

There is a third form of spore among the Powdery mildews. This is borne in pear-shaped bodies called pycnidia, and may be found among the filaments along with the young perithecia. The pycnidia of the gooseberry mildew are as shown in Fig. 2. The slender spores escape in great numbers through a pore near one end. These spores are doubtless for the rapid propagation of the fungus during its growing season.*

(*g*) CONDITIONS OF DEVELOPMENT AND REMEDIES.

As to the conditions favoring the growth of the gooseberry mildew the following quotations are offered from standard works upon fruit culture. Barry† says:

> In northern New York, in Maine, Vermont, and Lower Canada the finest large English varieties are brought to greater perfection than in warmer districts, and with good culture almost come up to the English standard. In a cold, damp, bottom soil at Toronto, almost on a level with Lake Ontario, fine crops are produced with comparatively little difficulty from mildew or rust. This would indicate as a remedy a cool soil and situation, and mulching the roots to keep them cool.

The last report of the American Pomological Society indicates, by a table of States, that the gooseberry is grown generally between the 35th and 45th parallels of latitude where there is a sufficient average rain-fall. Only a few States carry the double star for any variety, which is the index for their successful culture. Massachusetts, Michigan, Ohio, and Tennessee have each two varieties with two stars, and those States may be taken as indicating the range of territory best suited to gooseberries. Mr. Thomas‡ writes:

> Manuring, high culture, and pruning will in some cases prove sufficient to prevent mildew. This may be assisted by the cautious application of salt, either thinly over the soil or directly upon the plant; in the latter case the solution should be so thin that the saline taste may just be perceptible. Shading by a thick coat of salt hay appears to be an efficient remedy. It should be spread in a layer of several inches, or even a foot, in thickness, crowding it down to make room for the branches. This should be done in the spring.

Mr. Roe§ thinks that "repeated applications of the flowers of sulphur over the bushes from the time the fruit sets until it is ripe is probably the best preventive." Mr. Fuller‖ devotes the most space to the consideration of the gooseberry mildew, and says:

> There are many remedies which have been from time to time recommended, and they often appear to be effectual, while in other instances they are of no use whatever. The following remedies against mildew are worth trying, although they can not be called radical cures. Scatter flowers of sulphur over the bushes soon after the berries have set, and repeat the application occasionally until the fruit is ripe. Water the plants with strong soap-suds, or dissolve 1 pound of potash in a barrel of water and then sprinkle the plants once a week with it. Soak fresh-mown hay in brine for twelve hours; then cover the entire surface of the soil about the plant with this as a mulch. If hops, tan-bark, or other mulch has previously been applied, then sprinkle it with salt; a single handful to each plant will be sufficient. All of these remedies will often fail, but still they are worth trying. Old plants are more liable to suffer from mildew than young ones, therefore it is best to keep a supply of fresh

---

*See foot note, page 375.
† Barry's Fruit Garden, page 477.
‡ American Fruit Culturist, page 162.
§ Success with Small Fruits, page 226.
‖ Small Fruit Culturist, page 227.

plants always on hand; in fact, so long as you can keep the plants growing vigorously there is but little danger from mildew. I have often seen the foreign varieties doing splendidly in half-shady situations, such as the north side of a wall or fence, or in the shade of trees, but such a situation can not be recommended as the best, because mildew does destroy plants under just such circumstances. No effectual remedy can be given, nor the best locality pointed out, because the experiences of different cultivators are so conflicting that the one that appears to be the best in one locality would seem to be the poorest in another. Wherever the foreign kinds will grow without being attacked by mildew they are certainly far preferable to any of our native sorts; but my own remedy against mildew is to cultivate none but the native varieties, for with these I have never experienced the least trouble nor, as yet, had a berry affected by disease of any kind.

Mr. Fuller names Cluster, Downing, Houghton, and Mountain Sweet as the best American varieties.

From all that has been written and said upon the subject it is evident that the climate of our country is remarkably favorable for the development of the gooseberry mildew and especially upon the foreign varieties which are so successful in England and where upwards of two hundred "gooseberry shows" are held in a single season. Our wild species of gooseberry are better adapted to the peculiar climate that here obtains, and, even though some of them do mildew, it is evident that the leading steps of progress in gooseberry culture, must be taken by developing our native stock through judicious culture, breeding, crossing, etc. The European horticulturists started with native wild species and have achieved wonderful success, and it may be true that remarkable results may be obtained in this country. This would be striking at the root of the matter.

Until the experimenter can develop a variety that will withstand the mildew perfectly, the gooseberry-grower must resort to one or more of the standard remedies. It has been shown that the trouble is one confined to the surface and may be quite readily reached by fungicides. The gooseberry mildew is very similar in structure and habits to the Powdery mildew of the grape, and it is doubtless true that the same remedies will prove effective in both cases. The writers of fruit culture who have been quoted in this paper are in favor of placing flowers of sulphur first upon the list of remedies for the gooseberry mildew. They are perhaps not sufficiently emphatic in the statement that this substance should be applied early in the season and repeated at frequent intervals for two or three months.

It is evident that whatever is employed to destroy this mildew will be most effective when applied while the spores are least protected. Therefore, the remedy should be applied for killing the conidial spores just before they begin to ripen and for the ascospores before they become surrounded by the thick perithecial wall. The best time is when the perithecia are beginning to form and are still in a soft, tender condition. Best of all, the fungicide is most effective when applied while the mildew is first beginning to establish itself upon the host. This would be the application of the well-established principle of an ounce of prevention being worth a pound of cure.

The trouble is a living plant and, therefore, no rule can be laid down as to the dates of applying the substance to destroy it. It is a safe rule to sulphur the bushes as soon as the first leaves are fully formed, and repeat the process every ten days during the most rapid growth of the canes. This rule would cover the period of flowering and the early development of the fruit. If the young leaves and stems can be kept free there will be only little occasion for sulphuring the young fruit.

A preparation of sulphur, lime, and water called "liquid grison" has proved an effective remedy for the powdery mildews. Three pounds each of sulphur and lime are boiled in 6 gallons of water until the whole is reduced to 2 gallons. The clear liquid is poured off from the top and mixed with 100 parts of pure water, when the remedy is ready for use. The preparation is best applied through a spraying watering-pot or hose pump with a fine nozzle. This subject is fully treated under "powdery mildew of the grape" in Bulletin No. 2 of the Botanical Division, pp. 26–28. The gooseberry-grower who is troubled with the mildew should try one or more of the recommended remedies for the downy mildew of the grape, and note the results. The following is especially urged for trial: 1 pound powdered sulphate of copper, 10 pounds air-slaked lime, and 15 pounds flowers of sulphur. Mix thoroughly and apply with a sulphuring bellows. Evident success in the treatment of this disease has attended the use of sulphide of potassium. Spray the bushes when first attacked with a solution containing one-half to 1 ounce of the sulphide to the gallon of water.*

The Powdery mildews are lovers of dry, hot weather, and therefore care must be observed not to credit to any particular remedy what belongs to the season. Remedies need to be tested for a term of years to establish their value. With a proper use of fungicides and the improvement of our native species of *Ribes* and their crosses with foreign sorts, there is no reason why gooseberry culture may not be profitable in the United States.

14.—Smut of Indian Corn.†

Ustilago Zeæ-Mays.

(Plates XII, XIII, XIV, XV.)

(*a*) HISTORY.

Corn Smut, in common with the smuts of other cereals, has received the attention of agriculturists and botanists from an early time. The earliest article in which Corn Smut is distinctly treated and given a name was published anonymously in 1760; the name was *Lycoperdon Zeæ*.

Most early writers and even some in the first quarter of this century considered smuts to be excrescences or degenerations, products of the plant or a symptom of sickness. Linnæus and Jussieu, however, recognized them as plants. The Corn Smut was long considered only a variety of the wheat smut and first was designated a variety in 1805 by DeCandolle,‡ who called it *Uredo segetum*, var. *Mays Zeæ*. In 1808 this author refers it, apparently for the first time, to the subgenus *Ustilago*, and under that subgenus it is called *Uredo segetum* var. *Zeæ Mays*. In 1815 he recognized it as a distinct species and called it *Uredo Maydis*.

The first mention of it as an American fungus appears to be that of Schweinitz,§ in 1822, by whom it was called *Uredo* (*Ustilago*)

*Arthur, Sixth Rept. N.Y. Exper. Sta., 1887, p. 348.
†By A. B. Seymour.
‡Fl. Fr., II, 596.
§ Syn. Fung. Car., p. 71.

Zeæ and described as occurring in the ear. Some peculiarities in the description led Link, Tulasne, and European botanists who have followed them to suppose that it was different from the European form. Tulasne therefore called the American form *Ustilago Schweinitzii*, and in this he has been followed by Fischer de Waldheim in his recent works. But Ravenel,* as early as 1848 (the year after the publication of Tulasne's paper), stated that Schweinitz's and Tulasne's names were synonyms.

In the practical study of smuts, Prevost appears to have been the first to gain any valuable results. In 1807 he made the first observations on the germination of the spores and maintained that the smut as a parasitic fungus was the cause and not a mere accompaniment of the disease.

Meyen, in 1837, first studied the spore formation in the corn. His observations were partly confirmed by Léveille two years later. This was more fully made out by DeBary and published in 1853. In 1858 Kühn published the results of his investigations, which were quite complete as regards Indian Corn Smut. He left undetermined the mode of entrance of smuts into their host plants except of the bunt of wheat. This was discovered by Wolff for wheat smut and several other species, and soon afterwards by Kühn † for Indian corn. This apparently completed the cycle of development, but it was left for Brefeld to discover a mode of germination and growth wholly unsuspected. In previous attempts to germinate the spores they had been placed in water or a moist atmosphere. Brefeld sowed them at first by accident, in a nutrient solution, an infusion of manure. His mass of dry spores was accidently thrown to the floor, and a dust-like cloud of spores was scattered throughout the room. Some fell into a nutrient solution which was in use for other cultures and there germinated. This experiment was afterward repeated many times with the same result. They grew by budding like yeast and could continue to grow in that manner for an indefinite period; but when the nutriment was exhausted they would form mycelial hyphæ in the normal manner.‡

(*b*) EXTERNAL APPEARANCE.

(Plate XIII.)

There is nothing in the external appearance of the corn to indicate the presence of a parasite in its tissues until about the time of flowering. Then it shows itself in the form of swellings of such a nature that the Germans call it "boil smut." These swellings vary in size from that of a pea to more than that of a man's fist, and mark the place where the spores are formed. With few exceptions all the kinds of smuts, over one hundred in number, form their spores in some definite place in the plant, most commonly in the floral organs. Corn Smut is the most marked exception to this, for it forms its spore masses in any part of the plant except the roots.

---

* Fung. Car. Exs., IV, 100.

† Bot. Zeit., Vol. XXXII, p. 122.

‡ For fuller accounts of the history and literature of the smuts the reader is referred to the works of Tulasne, Fischer de Waldheim, and Brefeld.

FIG. 3.—Staminate flowers (tassel) infested by smut (after Peck).

The stem sometimes bears spore masses close to the surface of the ground, as stated by Kühn, and as observed also by the writer. From this place to the tips of the tassel they may occur at almost any point. The ear is oftenest affected, especially the grains of corn upon the ear (Plate XIII, Fig. 1). It is rare that all the grains are affected at once; there are almost always some good ones. The bracts at the base of the ovaries or young grains become greatly distorted (Plate XIII, Figs. 1–14), and the husks inclosing the ear much more so. When the smut forms a ring around the middle of the ear the grains above are often aborted (Plate XIII, Fig. 1). In the staminate flowers (tassel) the swellings are not so large. The presence of the fungus does or sometimes does not prevent the formation of pollen, and the swelling which precedes the appearance of the powdery mass is not usually formed till after the pollen ripens.

Less frequent, but by no means rare, are the spore masses in stems, leaves, and sheaths. Those on stems (Plate XII, *b*) often have a considerable size, but upon leaves especially they are smaller and less luxuriant in appearance, sometimes no larger than a pea.

The form of the swellings is in general rounded oblong, but usually broader at the free end and narrowed at the point of attachment. They are covered by a whitish or lead-colored membrane, tightly stretched at first, but later becoming wrinkled and bursting to allow the escape of a mass of powdery spores (Plate XIII, Fig. 13). If a swelling is cut open when young it appears slimy and spongy; in color uniformly whitish. An older one will be found to contain certain blackish spots or stripes (Plate XIII, Figs. 3, 8, and 14), and at length the whole mass becomes blackish-brown. At this stage the membrane bursts and the spores are blown away.

(c) THE FUNGUS.

The fungus is found within the corn plant when the latter is quite young, and during the vegetative period, up to the time when spore formation takes place it consists only of mycelium. This necessarily begins its growth near the surface of the ground, since it enters when the corn is very young, and as the latter grows in height the mycelium also grows upward toward the place where it is afterward to form its spores. It lies mostly parallel to the part in which it is growing, and in soft tissues extends as a uniform thread for a distance equal to the diameters of several plant cells; but at intervals, especially where the cell walls are firmer, branching takes place (Plate XIV, Figs. 1 and 2), and a plexus of filaments is frequently formed, as are also haustoria or suckers, the special organs for absorbing nutriment. These are most abundant in the leaves. The thicker the cell walls which the mycelium penetrates, the more plentiful are the suckers. The cob of a diseased ear contains numerous mycelial threads, penetrating between and through the cells, and is a favorable place for microscopic examination. The tips of mycelial threads are quite pointed and firm, which enables them to penetrate cell walls (Plate XIV, Fig. 2). When young the mycelium is so deli-

cate that it is seen with difficulty, but when older the walls of the filaments are thick and have a double contour, as of a tube within a tube, and the protoplasm is to be seen in the middle (Figs. 2 *a*, and 3). The color is a peculiar glistening opalescent or bluish-white; but the threads are often enveloped by a coating of cellulose and obscured by it so as not to be easily detected. It is difficult to trace the fungus from the place of entrance to that of spore formation because the intermediate mycelium dies out or is absorbed.

The fruiting time of the corn is also that of the fungus; and its spores are most commonly formed upon the young kernels or contiguous parts.

(*d*) SPORE FORMATION.

(Plate XIII, Figs. 15–17, and Plate XIV, Figs. 5–12.)

The first step toward spore formation is the branching of the mycelial threads in the place where spores are to be formed. The spore-forming threads branch in a bush-like manner, and the branches formed are very slender. These, in their turn, branch repeatedly; at length a very complicated mass of branches is formed. This increase in the fungus causes the swelling of the plant, and the maturing of the spores completes the swelling. The latter consists, in addition to the mass of fungus threads, of an abnormal multiplication of the tissues of the host plant. The tips of the branching threads become swollen and distended with protoplasm and have a color and appearance similar to that of the mycelium; in this protoplasm granules appear, each of which is to become a spore (Plate XVI, Figs. 9–11). These gradually increase in size and the filament becomes considerably distended, so as to resemble a short string or cluster of beads.

The development is now very active, and lateral protrusions or short branches are frequently formed. Soon cell walls are formed across the filaments, one between every two of the nuclear formations. The distending results in a roundish cell for each of these. The cell walls become gelatinous, which gives the slimy character to the mass of smut. As the spores approach maturity the gelatinous walls are gradually absorbed, as are also the mycelial threads, so that at maturity very little remains but the dry, dusty spores. Those in the center of the mass mature later than those outside, and when the latter are dry the former may be found still slimy.

The spores (Plate XIII, Fig. 17) are globose or roundish-oblong in form, and the central mass of protoplasm is inclosed by a double wall, the inner colorless, the outer brownish-black and thickly covered with slender points. This outer wall is similar to that of pollen grains. Their size is from .00036 inch to .00048 inch (9μ to 12μ), or about 25,000 laid side by side would measure an inch.

(*e*) GERMINATION.

Vitality of spores and time of germination.—Kühn states that the spores germinate with difficulty or not at all in water, but that in a moist atmosphere they germinate readily in October, and reach the formation of conidia in twenty-four hours. Fischer de Waldheim obtained similar results. Brefeld also failed to germinate the spores in water in the fall. He found, however, that in the spring ger-

mination took place in water very readily. He holds this to be the general rule. In April one-half the spores used in the experiment germinated in water in two days. According to his observations spores will retain their vitality for as long as two years. At that age they will not germinate in water, but will germinate in a nutritive solution. This takes place less readily than when they are about six months old, but having germinated they grow with as great activity as fresher spores.

Manner of germination.—When the spores germinate in water or a moist atmosphere the process is as follows: The inner coat and contents swell, burst the outer coat, and protrude as a tube (Plate XIV, Fig. 12, *a–d*) called the promycelium, into which the protoplasm passes. Several cross partitions are formed, dividing the filament into several cells. At these and at the tip spore-like bodies, conidia or sporidia, are formed (Plate XV, Fig. 1). In many species of smuts the sporidia unite or conjugate in pairs; their contents coalesce and from the resulting body a filament grows which may enter the tissues of the proper host plant. The Corn Smut, however, is especially characterized by the absence of this process. The sporidia germinate singly and produce mycelial threads (Plate XV, Fig. 4, *a*), which may penetrate the tissues of the corn plant.

This is the normal mode of germination, but another mode, discovered by Brefeld, is of great scientific interest and practical importance, and to neglect to consider it in practice may render all remedial efforts useless.

When the spores were sown in a nutritive solution the conidia did not germinate by tubes, as described above, but by budding like yeast (Plate XV, Figs. 3 and 4). The cells soon become detached from the spore, and the growth continues in this manner, each conidium producing, by budding, bodies like itself, which become detached and in turn form buds as before, and the entire growth is of this kind (Plate XV, Fig. 4).

But if the nutriment becomes exhausted, these yeast-like cells form mycelial filaments which bear conidia as when the spores germinate in water (Plate XV, Figs. 5 and 6). Brefeld's experiments were frequently made in a drop of the nutritive fluid, in order to keep them within bounds for microscopic examination. In some cases the experiment was varied by adding another drop when the nourishment in the one was exhausted, and when this was done the budding growth was renewed and continued as before. It was found that this mode of growth would go on indefinitely if nourishment was within reach of the fungus. This same thing has been found to take place in nature, in the dung of animals that have eaten smutty corn, and the same may be expected to take place when any smutty corn finds its way into manure piles. Thus its vitality may be preserved indefinitely, and it is ready to form mycelial tubes and enter the corn when the latter is planted in ground fertilized with such manure.

This form of the fungus being in active growth is perhaps in better condition to seize upon the young corn than the spores are, especially after the first spring.

Manner of entering the host.—For a long time all efforts to discover how the fungus gained entrance into its host were unsuccessful, except in the case of the bunt of wheat observed by Kühn. The mycelium was found in very young corn plants and hence was believed to gain entrance at some part of the plant near the surface of the ground. Wolff finally observed the penetration of several species of

smut, including that of wheat. It was Kühn* again who, sixteen years after his first results were published, finally discovered the penetration of the mycelium of Corn smut into its host. He found that mycelium from the germinating spores entered at the root node and the lowest joint of the stem, *i. e.*, at the most tender part, and only when the corn was young; when it is old the smut apparently can not get in. This may be turned to practical account in preventive measures as described under remedies.

(*f*) DISTRIBUTION AND SEVERITY.

Prof. William Trelease has recently found Corn Smut growing upon *Euchlæna luxurians*. With this exception it is confined to corn, so far as known, differing in this respect from *Ustilago segetum*, which grows on wheat, oats, barley, and various grasses.

It is distributed throughout Europe and America. In the cooler regions, what corn is cultivated is comparatively free from smut, but in regions well adapted to the culture of corn, it is often very destructive. In the valleys of the Rhine and Rhone it sometimes destroys nearly the whole crop. In the Rhine valley in 1880, the crop harvested scarcely replaced the corn used for seed. In the United States the extent of the injury is very variable. Mr. C. H. Peck records a case which occurred in 1868. He noticed a field of corn near Albany, N. Y., which just before flowering appeared as thrifty and promising as any in that county, but later almost every hill was attacked by smut, and at least one out of every four ears. It was especially injurious to sweet corn about Washington, D. C., in 1886.

Prof. B. D. Halsted† states that at Ames, Iowa, in 1886, the college corn-field had sixty-two hundredths of 1 per cent. of the ears smutted. Prof. C. E. Bessey states that a destruction of 15 per cent. frequently occurs, and in one field he observed 66 per cent. of the corn smutty.

It is generally believed that wet weather is favorable to smut, and that corn is likely to be, and is, badly damaged in a wet season. A correspondent of the Country Gentleman, in September, 1878, writes that a wet season has been accompanied by much smut. Tulasne states that in 1846, a dry season, the corn crop in the valley of the Rhone was partly destroyed, and says the smut may be very injurious in very dry years. Prof. W. H. Henry states that the smut was very destructive about Madison, Wis., in 1881, causing a loss of 5 to 25 per cent. of the whole crop, while in 1882 there was very little smut. The writer observed that corn was badly smutted in northern Illinois in the summer of 1881, which was very dry.‡

(*g*) NATURE OF INJURY CAUSED BY CORN SMUT.

During nearly the whole growth of the corn the fungus is growing within it. It produces little apparent effect until the time of fruiting,

*Bot. Zeit., Vol. XXXII, p. 122.

†Bull. Iowa Agr. Col., Nov., 1886. Professor Halsted writes me, the summer of 1887, like that of 1886, was a very dry one at Ames, and that in 1887 the smut was very abundant.

‡In many corn-fields in Texas, as far west as El Paso, I observed more or less Corn Smut the past summer. The season was very dry.—F. L. S.

but at all times it takes from the plant some of the materials the latter prepares for its own growth. At the time of fruiting the amount thus taken is very large, necessarily weakening the activity of the plant, and especially injuring such of the grain as is not directly infested and destroyed. This is very evident when the smut is formed in the middle of the ear and the grains above are aborted. But an ear having any smut at all is practically destroyed. It can not be fed to cattle, because the spores will get into the manure and spread the infection. Smutty fodder can not be used for the same reason. The smut is believed to be poisonous to cattle, and many cases of injury or death have occurred supposed to result from feeding smutty ears or fodder. In medicine Corn Smut is used to some extent in place of ergot, its action on the animal system being the same.

It is worthy of notice that the time of greatest injury to corn from smut is at the time of fruiting. It may be that the great effort on the part of the plant to mature its fruit leaves it less physiological power to resist the parasite, and it is at this time that an abundance of material suited to the growth of the fungus is formed, especially in the ear.

(*h*) TREATMENT.

It is as certain that Corn Smut can not originate spontaneously as that the corn itself must grow from seed. The destruction of the spores, then, means the reduction of the smut sooner or later; but co-operation over wide areas is necessary, since the spores are light and may be carried in the atmosphere more easily than ordinary dust particles. Any remedy must be thoroughly tried before being condemned for apparent failure (one year is not sufficient), and every source of error must be guarded against. However carefully the smut is cut out and burned, if manure with which is intermixed smut of previous years is applied to the land the remedy will probably be ineffective, because the spores germinate in the manure.

Destructive treatment.—Cutting out should be practiced intelligently and persistently, and farmers should co-operate. The smut should be cut out as early as possible as soon as it gives the first evidence of its presence by the swellings it produces and before any of the spores burst through the epidermis. Corn is probably the only crop in which the smut becomes evident long enough before maturity to make treatment effectual, or at least possible. As soon as the spores begin to break out they will be scattered far and wide over the whole field. Any ears that are partly smutted and are overlooked till the husking should not be thrown in with the rest of the corn, for two reasons: They will scatter their spores, and if in large quantities will injure the cattle eating them. If any smutty stalks are standing when the corn is cut they should not be cut with the rest, but kept separate and destroyed. Masses of smut are greedily swallowed by cattle with the rest of the corn, and are liable to produce disease and death. A correspondent of the Country Gentleman, September 12, 1878, reports the loss of several head of cattle and sheep from this cause. Diseased parts cut out should be completely destroyed, not thrown upon the ground nor into a manure or compost pile. The spores may germinate and grow for an indefinite period, as already shown, and when the manure is applied to the field they will be ready to seize upon young corn and pene-

trate its tissues. One writer suggests feeding to pigs; but this should never be done, for if the smut does not injure the pigs the spores will pass through the intestines without injury to themselves and infect the manure.

Farmers will urge that they can not afford the time or money necessary to cut out the smut. In answer to this objection Professor Bessey makes the following estimate:*

A 40-acre field should produce at least $800 worth of corn. There is rarely less than one smutty ear to one square rod. This amount would be 2 per cent. of the crop and would be worth $16. Each additional smutty ear per square rod destroys $16 worth of corn in the field. Will it not pay to save annually a loss of 2 per cent. and upward, and occasionally a loss of 15 to 25 per cent., $120 to $200, for a field of this size?

Selection of seed.—Much may be gained by selecting for seed the largest and most perfectly developed grains. Experiments have shown that this will insure a larger yield, and it is also true [?] that corn from such seed is less liable to suffer from smut. Weak plants can offer less resistance to the attack of the fungus, as a weak man can less effectively resist disease. Thrifty plants can better withstand the smut if it gains entrance, and are more likely to escape its entrance, because they more quickly pass the stage at which the smut is known to enter them.

Application of remedies.—Any outward application to the growing corn would be useless if it could be made, because the fungus is entirely within the tissues of the host until after the damage is done.

Various applications have been tried to destroy spores adhering to grains. They have been made for this purpose to wheat, and there is no apparent reason why a remedy whould not be as effectual in one case as the other. It seems to be generally agreed that lime water is not effective. A weak solution ($\frac{3}{4}$ per cent.) of sulphuric acid is recommended for corn by some German experimenters.

Copper sulphate (blue vitriol) has been most used and with good results. One experimenter with copper sulphate for Corn smut records that no perceptible benefit was gained. If he fertilized the field with manure in any way infected by smut spores, which is not unlikely, it would be a sufficient reason to explain the failure. The method of application which prevails in Europe differs from the American method. The former is fully described by Sorauer in his work on plant diseases. He recommends a weak solution and long soaking; a $\frac{1}{2}$ per cent. solution of sulphate of copper and sixteen hours soaking he considers best. The solution should cover the corn deeply enough so that none shall be exposed when the latter swells, and the mass should be stirred well and all the grains that float skimmed off.

Sorauer states that a 1 per cent. solution kills 4 per cent. of the seed in twelve to sixteen hours. After soaking, the grain is spread out on a flat surface to dry, and it should be sown soon afterwards. It is dry enough for hand sowing in a few hours and for the drill in twenty-four hours.

The practice in America is quite different. Strong solutions are used and the grain is immersed only a short time. The following descriptions of the process as applied to wheat are by men who have had practical experience and know how to make the treatment effective:

* Bulletin Iowa Agricultural College, 1884, p. 129.

From a published letter by Hon. Horace Davis, member of Congress from San Francisco, and the largest miller on the Pacific Slope:

In early times we were much troubled with smutty wheat, but have little now, owing to the use of blue-stone on the seed by the farmers. I have seen fields where part of the seed was treated with blue-stone and part not, and the difference was as plain as between a field of barley and of oats. It is hard to give any exact rule as to application; the most practical farmers tell me they use 6 pounds to each ton of seed-wheat. It is dissolved in water enough to wet this quantity of wheat, and the wheat is put into bags, say 50 to 60 pounds, and immersed in the solution for six or seven minutes, just enough to wet all the wheat. Then it is taken out and laid on sloping boards at the end of the trough to drain. The solution is put into a trough built for this purpose, something like a horse-trough. The bags are turned over frequently in this solution to insure the wetting of all the wheat. You can rely upon it that blue-stone is a dead shot for smut in California. By blue-stone I mean the sulphate of copper.

Extract from a published letter on this subject by Prof. E. W. Hilgard, University of California, College of Agriculture:

As regards the blue-stoning of seed-wheat, the solution used is as strong as it can be made at the ordinary temperature. Such a solution contains about 3 pounds of blue-stone to 5 quarts of water. The time of immersion varies somewhat; the most definite description given is that a half sack should remain in the saturated solution at least three minutes, and be turned about several times in the interval to make sure of wetting thoroughly. When a weaker solution is used the grain may be left with it until it begins to sprout. The sacks are usually left unopened until used for sowing. There is no drying done on purpose, unless it is to be used in the seed-drill. It will work perfectly with the centrifugal sower without drying. In general I would be in favor of the strong solution and short immersion. The work is then done quicker, and if the grain is afterward left in the sack for some hours the application is sure to be effectual. Again, the strong solution is more certain to render the grain distasteful to birds and insect enemies, and gives a margin for killing fungoid germs round about the young seedling. There seems to be little danger to the vitality of the seed from the blue-stone. Of course the blue-stone will not prevent the smut germs left over in the fields from previous seasons from attacking the developed plant. It simply kills the germs in [on] the seed that would otherwise develop along with the latter, and take the plant in its early stages. A field that has been very smutty during the previous season will be apt to show some on the grain of the next one despite blue-stoning, but persistence in the practice will be sure to put an end to the fungus germs, save so far as they may be furnished by kind neighbors above the wind.

Prof. M. A. Scovell, director of the Kentucky Experiment Station, writes as follows in the bulletin of the station of September, 1887, p. 14:

This disease (smut) was in all our wheat last year, consequently our seed-wheat contained smut grains. To prevent its recurrence this year all our varieties of wheat were treated with a solution of blue vitriol (blue-stone) before sowing. The method of applying the solution of blue vitriol was as follows: Ten pounds of blue vitriol were dissolved in 8 gallons of water, and the solution placed in a tub. The seed-wheat was put into the solution and well stirred, care being taken not to put enough wheat in to come to the top of the solution. After skimming off floating wheat and particles, the solution was poured off into a second tub, the wheat drained, and spread on boards to dry. The solution was re-used as often as we had wheat to treat in this manner.

This treatment proved entirely successful, not the least smut appearing in any of the plots where the seed had been treated in this way, while the plot planted for comparison, without treating the seed wheat, contained about the same amount of smut as last year.

It was thought that by having the solution cover the wheat the smut grains would float, and in this way all but adhering spores would be removed, and these would be easily killed by the copper sulphate solution.

All other preventive measures will be likely to be of little avail if the manure put upon the land is contaminated with smut spores

from smutty corn fed to stock, or smutty stalks thrown into the manure pile, or from whatever source.*

Brefeld's investigations, described under germination, show how manure may spread infection. A direct demonstration of this point by Morini is quoted by Sorauer. Bran with which Corn smut spores were mixed was fed to a cow. The dung in which the spores were found germinating was put upon a piece of land with corn seed. The resulting growth of corn was, as a whole, smutty. Of thirty others dampened with gum water and covered with ungerminated spores only four plants were smutty. This shows the injury that may come from spores germinating in manure. It does not prove that passing through the animal makes them more active. In Brefeld's experiments, on the contrary, nearly all spores sown in a nutritive solution in the spring germinated within twenty-four hours. It shows that every precaution should be taken to keep the smut away from stock and out of manure piles. Burying the smut deeply suggests itself as a convenient and efficient means of disposing of it. Burning is effective, but care must be taken that spores shall not be carried away and scattered by currents of air about the fire. Rotation of crops should be practiced for evident reasons.

In Europe two other species of smut occur in Corn and both are most prevalent in Italy. *Ustilago Fischeri*, Pass., attacks the cob, and in Italy, especially about Parma, sometimes destroys half the crop. *Ustilago Reiliana* was introduced into Italy on sorghum from Egypt, and in the former country it grows also on corn, attacking the flowers of the tassels.

15.—Corn rust.

Puccinia Maydis, Carr.

(Plate XVI.)

(*a*) history.

Mention of the Corn Rust is conspicuously absent in the works of leading mycologists in the early part of this century. Probably it was not common in Europe at that time and it may have been confounded with other species.

The only mention of it in those early years, so far as known, was by an Italian writer, Carradori,† whose name is scarcely known otherwise to mycologists. He described it in 1815 under the name *Puccinia maydis*. Schweinitz‡ (1834) is the next to mention it, and the first to record it as American under the name of *Puccinia sorghi*. Later several European botanists gave it names, each one supposing that he had found it for the first time. It causes less injury than

---

*When stable or barn-yard manure is used as a fertilizer a possible prevention of smut might be found in David's powder (see page 328).

Immediately previous to planting, the seed-corn should be wet, and while in this condition thoroughly raked over in the powder: or, a spoonful of the powder should be dropped along with the seed in each hill. Avoid handling the powder with the naked hands.—F. L. S.

†Gioru di Fisica, etc., del Brugnatelli, 1815, Vol. VIII. See Just. Jahresbericht, 1876, p. 152.

‡Syn. Fung. Am. Bor., p. 295.

the smut and consequently has received less attention from practical men. Its life history has not been especially studied, but that of several related species have been studied very fully. The best practical article upon it in English is that by Mr. C. H. Peck in his thirty-fourth report.

(*b*) EXTERNAL APPEARANCE.

Corn rust is very similar to the rust of wheat, but still specifically distinct. It does not grow upon the floral organs, but so far as observed is confined to the foliage, where it appears as small pustules. After the middle of the summer the pustules begin to appear on either or both surfaces of the leaves. At first they are covered by the epidermis and are whitish, but they soon swell sufficiently to break the latter, whose lacerated edges may be seen standing up around them. Thus the pustules become exposed, and at the same time the spores which they contain are matured and ready to be disseminated. The pustules (called sori) are collections of spores. The sori are roundish, or oftener somewhat elongated in form, scattered irregularly; but sometimes they are clustered, and then they tend to be arranged in lines parallel to the length of the leaf.

The earlier pustules, if examined carefully, will be found of a bright, rich, yellowish-brown color; the later ones almost black.

(*c*) THE FUNGUS.

This difference in color indicates two different kinds of spores; but they are frequently found intermingled in the same pustule, and are produced from the same vegetative fungus threads (mycelium) within the leaf. The brown spores (uredospores), which are the earlier, correspond to the so-called red rust of the wheat. A section through a pustule shows that each spore is borne on a slender stalk, from which it easily falls. The shape is nearly spherical (Plate XVI, Fig. 2), and the comparatively thick wall or coat of the spore is covered with minute projections. The diameter is about one one-thousandth of an inch or a trifle more. In the protoplasmic contents drops of oil are sometimes seen. The vitality of the spores is of short duration. They must germinate within a limited time if at all. It is believed that they are killed by becoming dry, and that they do not survive the winter. The black pustules (Plate XVI, Fig. 1) are composed of dark-colored spores (teleutospores) having a very different structure and function. The stalks which bear them are stronger and do not separate from them. Each spore is broadly elliptical in outline, with both ends rounded, or with the apex occasionally thickened and pointed (Plate XVI, Fig. 3). The surface is smooth. A partition is placed across the middle which divides the interior of the spore into two cavities. At germination each part may germinate independently, so that this may be called a double spore. At the partition the spore is constricted and it is twice as long as broad; some are a half longer and broader than others, and the largest are a little narrower than the diameter of the uredospores. They measure .0006 to .0009 inch by .0012, to .0018 inch. These may be called resting spores, because they remain dormant through the winter and germinate the next season, again producing the rust and thus perpetuating its existence. It is not known to have any third form of spores (æcidium) such as the common wheat rust produces upon the barberry.

(*d*) SEVERITY.

The fungus is always injurious to the corn on which it grows, but the extent of the injury depends largely on the age and condition of the corn and climatic conditions, and is often so slight as to be of no practical importance. Certain conditions of the weather may retard the growth of the corn and favor that of the rust. Ordinarily the rust is not noticed till the latter part of the summer, when the corn is well grown and not easily injured; but in the first week of July, 1886, the writer observed it repeatedly on the lower leaves of partly-grown corn, whose vigor was plainly impaired by it.

The injury consists (1) in loss of food materials elaborated by the plant for its own growth, which the threads (mycelium) of the fungus, ramifying in the tissues of the corn, absorb for their growth and the formation of spores; (2) in destroying the power of some of the tissues to do their work, and of the chlorophyll contained in them to continue the elaboration of fresh food supplies for the corn. When coming early in the season the rust is likely to be more than usually injurious later in the same year, and to continue so the year following.

Thus far the experiments made in combating the rusts have yielded no positive results.

16.—ERINOSE.

Phytoptus vitis.

(Plate XVII.)

(*a*) GENERAL OBSERVATIONS.

The name Erinose is here adopted to designate a special disease of the leaves of the grape-vine caused by a minute acarid, the *Phytoptus vitis.* Formerly the peculiar effects produced by this *Phytoptus*, as well as those caused by other species which infest the alder, maple, beech, etc., were thought to be fungi, and were all included by the older mycologists in the genus *Erineum.* In the case of the vine, the effect produced by this little animal parasite bears a strong resemblance to the external appearance of the downy mildew, and samples have been sent to us from various parts of the country under the supposition that the leaves were infested with the Peronospora. As it is very important to be able to distinguish the one, which is always to be dreaded, from the other which rarely if ever does any serious injury, the peculiar characters of Erinose will be here pointed out.

(*b*) EXTERNAL APPEARANCE.

Erinose usually appears in early summer in the form of raised, lustrous white spots on the lower surface of the leaves. The color soon becomes yellow, and finally a dark reddish-brown. The spots, usually small and scattered irregularly over the surface between the nerves, are sometimes of considerable size, and we have occasionally found leaves of *Vitis æstivalis* with their lower surfaces entirely covered by Erinose. There is no evidence of the disease on the upper surface of the affected leaves in the wild or cultivated vines of the Eastern and Middle States. If attacked while young they

may be prevented from attaining a normal size, and when badly infested they become more or less curled, with the convex side uppermost. On the upper surface of leaves of *Vitis vinifera* and its varieties, however, the disease shows not in any discolorations, but opposite the spots beneath there are conspicuously raised areas imparting to the surface a blistered appearance. This results from a greater growth or multiplication of cells in the diseased areas than in the surrounding unaffected portions.

(*c*) MINUTE CHARACTERS (Fig. 1).

If the lustrous white, or later yellowish, spots are examined with a good lens or magnifying glass they will appear to be composed of a dense growth of shining hairs (Fig. 1, *a*, *a*), with somewhat enlarged tips, and this is their true character, as may be determined by a microscopical examination. There is no longer any danger of mistaking these hair-like growths for the downy mildew, for when viewed under the microscope there is not even the slightest resemblance between them, as may be seen by comparing Fig. 2, Plate XVII, of this report, with Fig. 10, Plate I, in the annual report for 1886. In the former figure, which illustrates a transverse section through one of the spots affected with Erinose, the microscopical characters of the disease are illustrated. The cells composing the tissues of the leaf are seen to be abnormal in their development, while the epidermal cells of the lower surface are elongated into hair-like projections, sometimes branched above, and with rounded and more or less club-shaped tips. The cause of this abnormal growth is the Acarid, two specimens of which (Fig. 2, *b b*) are shown in the figure equally magnified with the section. To the naked eye they are barely visible, even when placed upon a surface of contrasting color; it is quite impossible to detect them on the spots without a good magnifying glass. These parasites puncture the epidermal cells of the leaf, from the irritating or poisoning effects of which the abnormal growths and consequent spots are developed.

Phytoptus vitis lives mostly in the larval state, the condition illustrated in our figure. The adult stage is found only in the spring, and then but for a brief period. When it comes out of the egg it possesses four feet, situated upon the anterior part of the body, which is composed of several rings; the skin is striated and furnished with four stiff hairs upon each side of the body, and two long bristles are fixed in the posterior extremity. The larvæ multiply during the summer by means of parthenogenetic eggs (Fig. 2, *c*). At the approach of winter they become encysted and hibernate under the scales of the buds or in crevices of the bark. In the spring the cysts are ruptured and from them come six-footed larvæ, which soon develop two additional feet, thus passing into the mature stage. The adults die immediately after the eggs are laid, the latter giving rise to the four-footed larvæ above described.*

(*d*) DISTRIBUTION, EFFECTS, AND TREATMENT.

Erinose is widely distributed throughout the country, and may be looked for wherever the vine is cultivated. We have seen it in New Jersey, District of Columbia, Texas, and California. It is nowhere particularly injurious, and only in very rare cases does it ever make

*P. Viala, "Les Maladies de la Vigne," p. 451.

any difference in the quantity or quality of the crop. If, however, it attacks very young leaves it may be harmful and some treatment be necessary. Repeated applications of sulphur, made when the shoots are 3 to 5 inches long, will check the multplication of the *Phytoptus*. Washing the vines after they are pruned in early spring with boiling water will destroy the eggs and larvæ concealed within the bud scales and crevices of the bark.

F. LAMSON SCRIBNER.

Hon. NORMAN J. COLMAN, *Commissioner.*

EXPLANATION OF PLATES.

PLATE I.

STRAWBERRY-LEAF BLIGHT (SPHÆRELLA FRAGARIÆ).

FIG. *a*. Diseased leaf, natural size, attacked by the summer stage of the fungus. (G. M., pinx.)
FIG. *b*. Tuft of conidiophores and conidia which have broken through the upper epidermis. (E. A. S., del.)
FIG. *c*. Conidia more highly magnified; three of them have sent out germ filaments. (E. A. S., del.)
FIG. *d*. Perithecium bearing conidiophores around the ostiolum. (E. A. S., del.)
FIG. *e*. Section of perithecium, showing asci within. The asci are borne upon a small mass of parenchyma at their base. *a* Ostiolum. (E. A. S., del.)
FIG. *f*. Five asci containing ascospores; much enlarged. (E. A. S., del.)
FIG. *g*. Ascospores. (E. A. S., del.)

PLATE II.

APPLE SCAB (FUSICLADIUM DENDRITICUM).

FIG. 1. Shows the scab on the fruit.
FIG. 2. A leaf attacked by the scab fungus.
FIG. 3. A section through a portion of one of the spots on the fruit, showing the growth of the fungus; greatly magnified.
FIG. 4. Spores of the fungus, greatly magnified; four of them germinating.

PLATE III.

BITTER-ROT OF APPLES (GLŒOSPORIUM FRUCTIGENUM?).—LEAF-RUST OF CHERRY (PUCCINIA PRUNI-SPINOSÆ).—BEET-RUST (UROMYCES BETÆ).

FIG. 1. Section through piece of rotten apple showing an old pycnidium: *a*, thick epidermis of fruit: *b*, fruit perenchyma; *c*, mycelium in tissues. The hyphæ surrounding the pycnidium are composed of a series of short cells.
FIG. 2. Section showing pycnidium and hyphæ after the formation of spores has ceased; *a*, mycelium in fruit tissues.
FIG. 3. *A*, tuft of spore-bearing hyphæ; *a*, spore. *B*, spores much enlarged; *a*, surface view; *b*, optical section.
FIG. 4. Germinating spores twenty-four hours in water; showing dark bodies formed on the germ filaments.
FIG. 5. Germinating spores eight hours in water.
FIG. 6. Uredospores of *Puccinia pruni-spinosæ* on peach.
FIG. 7. Same on plum: *a* and *b*, in germination; *c*, *c*, germ pores.
FIG. 8. Paraphyses found abundantly in sori of *Puccinia pruni-spinosæ*.
FIG. 9. Teleutospores of same on plum: *a a*, surface view; *b b*, optical section.
FIG. 10. Section through portion of sorus (uredo-stage) of *Uromyces betæ*: *a a*. cells of leaf tissue entirely surrounded by mycelium; *b*, ruptured epidermis; *c*, spores; *d d*, pedicels from which the spores have fallen. The mycelium masses together in spots beneath the epidermis forming a stroma on which the spores are borne.
FIG. 11. Uredospores of same: *a*, germ pore.

Plate IV.

COTTON-LEAF BLIGHT (CERCOSPORA GOSSYPINA).

Fig. 1. Diseased leaves, natural size. (R. C., pinx.)
Fig. 2. Showing a tuft of dark-colored fruiting hyphæ rising from the mycelium within the leaf and issuing through the epidermis. Above are shown the long, colorless, septate spores. (E. A. S., del.)

Plate V.

ANTHRACNOSE OF RASPBERRY (GLŒOSPORIUM VENETUM).

Fig. 1. Branch, natural size, showing appearance of disease upon the cane and leaves, and its effect on the berries. The upper portion of the cane is quite dead, and the diseased spots extend down on the green portion, along the branch and stalk that bears the berries, and over the petiole and midribs of the leaf and leaflets. The berries remain unripened, owing to the effects of the disease. (R. C., pinx.)
Fig. 2. Section through a diseased spot on the cane, showing destruction of the outer layers of tissue, and the spores (*a*) borne on the surface and center of the spot. (F. L. S., del.)
Fig. 3. Spores, showing two in process of germination. (F. L. S., del.)

Plate VI.

ANTHRACNOSE OF THE BEAN (GLŒOSPORIUM LINDEMUTHIANUM).

Fig. 1. Diseased pods, natural size. (R. C., pinx.)
Fig. 2. Section through a diseased pod. The section is taken between two beans, consequently shows none in the cavity. The diseased portions (*a*) are dark colored; *b*, exocarp; *c*, endocarp. (E. A. S., del.)
Fig. 3. Another section through a diseased pod, showing an advanced stage of the disease and a diseased bean (*b*) inside the pod; *a*, diseased spot, one entire side of the pod is diseased and shrunken; *c*, small diseased spots where the fungus has not penetrated through the exocarp. (E. A. S., del.)
Fig. 4. Section through a fruiting pustule: *a*, ruptured epidermis; *b*, mycelium; *c*, conidiophores; *d*, brown hyphæ; *e*, spores. (E. A. S., del.)
Fig. 5. Spores, highly magnified. (E. A. S., del.)

Plate VII.

CATALPA-LEAF SPOT DISEASE.

Fig. 1. Section through leaf at the union of a diseased spot with the healthy tissue: *a*, healthy tissue; *b*, diseased spot, in which the cell outlines have almost entirely disappeared.
Fig. 2. Tuft of *Macrosporium catalpæ* emerging from a stoma; *a a*, spore-bearing hyphæ; *b b*, spores; *c*, very young spore.
Fig. 3. Germinating spores of *Macrosporium*.
Fig. 4. Pycnidium, or fruiting body of *Phyllosticta catalpæ*. The pycnidium is partially sunken in the tissues of the diseased leaf, and the spores are borne on rather long basidia which line the inside of the conceptacle.
Fig. 5. Spores, more highly magnified.
Fig. 6. Spores, germinating after forty-two hours in water.

Plate VIII.

BLACK SPOT ON ROSE LEAVES (ACTINONEMA ROSÆ).

Fig. 1. Diseased leaf, natural size. (R. C., pinx.)
Fig. 2. Enlarged portion of leaf at edge of spot, showing the apparently superficial mycelium and two fruiting pustules. (R. C., pinx.)
Fig. 3. Branching strand of superficial mycelium. (E. A. S., del.)

PLATE IX.

BLACK SPOT ON ROSE LEAVES (ACTINONEMA ROSÆ)—ROSE PHRAGMIDIUM (PHRAGMIDIUM SPECIOSUM).

FIG. 1. Section through healthy rose leaf: *a*, cuticle of upper surface; *b*, upper epidermal cells; *c*, two rows of palisade cells; *d*, loose parenchyma; *e*, lower epidermis; *f*, cuticle of lower surface. All except the epidermal cells are partly filled with chlorophyll bodies. (E. A. S., del.)

FIG. 2. Section through rose leaf attacked by *Actinonema*, showing an early stage of the disease. The upper epidermal cells are partly filled with a dark, homogeneous mass, consisting of the transformed cell contents; the chlorophyll bodies in the upper row of palisade cells are disorganized, and the process of disorganization has begun in the lower row; *a* shows the hyphæ between the cuticle and the epidermis; *b*, cuticle that has been ruptured by the formation of spores beneath; *c*, spores borne on an indistinct mass of mycelium; *d*, the mycelium can be seen in the cells of the upper epidermis, and evidently pushes into or between the palisade cells, although it can not be distinguished below the epidermis. (E. A. S., del.)

FIG. 3. Very advanced stage of the same. The disorganization of cell contents has progressed through the leaf, and the cells are shrunken so as to show the mycelium between them. Most of the spores have escaped from the fruiting pustule. (E. A. S., del.)

FIG. 4. Spores of same, much enlarged. (E. A. S., del.)

FIG. 5. Teleutospore of *Phragmidium mucronatum*, showing long stalk thickened towards the base. (F. L. S., del.)

FIG. 6. Fragment of rose stem affected by *Phragmidium speciosum*. (R. C., del.)

FIG. 7. Teleutospores of *P. speciosum*. (F. L. S., del.)

FIG. 8. Same, more enlarged and without pedicel. (F. L. S., del.)

PLATE X.

ROSE RUST (PHRAGMIDIUM MUCRONATUM).

FIG. 1. Branch of *Rosa blanda*, natural size, showing appearance of the disease in the Æcidio-stage on the stem and leaves; at *a* the branch has been bent from the effects of the fungus. (R. C., pinx.)

FIG. 2. Leaf attacked by Uredo and Phragmidio-stages; the latter is represented by the darker spots. (R. C., pinx.)

FIG. 3. Æcidio-stage. Section through diseased spot occurring on a vein; the spores are borne in chains over the back of the vein, and a few paraphyses (*a a*) may be seen at the circumference of the spot. (F. L. S., del.)

FIG. 4. Uredo-stage. Cluster of spores and paraphyses. (F. L. S., del.)

FIG. 5. Æcidiospores. (F. L. S., del.)

FIG. 6. Uredospores, separated from their pedicels. (F. L. S., del.)

FIG. 7. Teleutospores.

PLATE XI.

POWDERY MILDEW OF GOOSEBERRY (SPHÆROTHECA MORS-UVÆ).

FIG. 1. Mycelium with conidiophores and conidia in rows, as found on the surface of the leaf: *a*, conidiophore; *b*, conidium. Two conidia are represented as having become detached.

FIG. 2. Three of the so-called "pycnidia" of the fungus. Two are represented as discharging their spores. (After Tulasne.)

FIG. 3. The male (*a*) and female (*b*) cell united for the production of the perithecium.

FIG. 4. A young perithecium.

FIG. 5. A perithecium nearly full grown, showing appendages.

FIG. 6. Ripe perithecium broken open and the spore sac (ascus) coming out.

FIG. 7. An ascus, showing the eight spores.

PLATE XII.

SMUT OF INDIAN CORN (USTILAGO ZEA-MAIZE).

FIG. From photograph, illustrating the appearance of the disease in the ear (*a*) and on the stalk (*b*).

PLATE XIII.

SAME (AFTER TULASNE). ILLUSTRATING THE EFFECTS OF THE DISEASE.

[Figs. 15, 16, and 17 represent the objects magnified about 460 times; all others natural size.]

FIG. 1. Portion of a smutty ear of white corn; at the base are some sound and ripe grains (*g*); above, the female flowers remain sterile (*s*), and the bracts merely cover the abortive ovaries; the bodies (*c c*) are bracts made numerous by the influence of the *Ustilago*, which is there developed.

FIG. 2. Young ovary inclosed by bracts and, like them, swollen by the presence of the endophyte; the style is strongly bent down on the inner side.

FIG. 3. Vertical section of these organs; the wall of the ovary is very thick on the outer side and thin on the inner; a rudiment of the ovule is situated at the base; the black spots in the thickness of the bracts and the wall of the ovary indicate the formation at these points of the black powder of the *Ustilago*.

FIG. 4. Another smutty ovary cut vertically, in which, besides the rudiment of the ovule, is found a thin membrane, ordinarily not smutty, and which is united below with the inner surface of the ovary.

FIG. 5. A bract or husk deformed and monstrously enlarged by the continued development of the smut in its tissue.

FIG. 6. Transverse section of this bract, in which the presence of the endophyte is indicated only in one part, although it occupies uniformly all the tissues of the organ.

FIG. 7. Another smutty bract.

FIG. 8. Transverse section of the same.

FIG. 9. Another of different form.

FIG. 10. Horizontal section of 9.

FIG. 11. Two smutty bracts partly united.

FIG. 12. Transverse section of Fig. 11.

FIG. 13. Another, more monstrous than the preceding.

FIG. 14. Horizontal section of 13 (sketch incomplete). The husks acquire, under the influence of the *Ustilago*, a much greater development than the ovaries, which sometimes fail almost completely.

FIG. 15. Fragment of the mucilaginous material of the *Ustilago*, in which are immersed innumerable spores not yet mature.

FIG. 16. Another fragment in which the spores are less developed than in the preceding; on one side of this figure are shown filaments such as are abundant in the cavities occupied by the endophyte.

FIG. 17. Dry spores.

PLATE XIV.

SAME, ILLUSTRATING THE MYCELIUM, ETC.

FIG. 1. Long, extended threads beginning to ramify, running through a pith cell (in which a nucleus is still to be seen). From the second internode below a blighted rachis.

FIG. 2. A long, extended thread covered with a cellulose sheath and passing through many cells. At *a* the thread shows through, at *b* is seen the section of the cut sheath and of the thread. Cut lengthwise through the rachis at the bottom of the ovary.

FIG. 3. The previous figure at *a*; a conspicuous piece of thread; in the thread is seen the contents; the cellulose sheath is strongly marked.

FIG. 4. Threads which have become distinctly visible in the cellulose sheath by the application of potash and iodine. Shown detached from a cell of the ovary wall.

FIG. 5. Thin-walled threads (like the transition form in the spore forming threads), with many shoots and fine-grained contents. Parenchyma of ovary wall cut lengthwise.

FIG. 6. Thread become gelatinous; the contents is indistinctly seen. From a gelatinous spore mass.

FIG. 7. Spore forming threads, with bright oleaginous contents running between the cells. Ovary cut lengthwise.

FIG. 8. Gelatinous thread, with a distinct breaking up of the contents for spore formation; the upper part represents the same conditions as Fig. 2. Its course between the cells was still, in part, distinctly perceivable.

FIG. 9. More transparent spores forming in the interior of the gelatinous thread.

FIG. 10. The same; however, a great number of the transparent spores are seen lying in a row, lengthwise in the stem. The latter appear more transparent.

FIG. 11. A spore become brownish, surrounded by the gelatinous membrane of the thread. From the ovary wall.

FIG. 12. *a*, promycelium with a projection; twenty-four hours; *b*, spore germination later with a straight promycelium; forty-eight hours; *c*, the same with the promycelium bent in a knee form; *d*, formation of a lateral sporidium (after twenty-four hours). Highly magnified.

FIG. 13. An affected ovary cut lengthwise; the masses of ripe spores appear as black spots or stripes.

PLATE XV.

SAME, GERMINATION OF SPORES IN WATER AND NUTRITIVE SOLUTIONS.

(Figs. 30-35, after Brefeld.)

FIG. 1. Germination of spores in water and bearing conidia.

FIG. 2. Older germinating spores. The conidia have fallen, some cells of the conidiophores have become empty, others have developed into filaments.

FIG. 3. Germination of spores in a nutritive solution, showing the more strongly developed conidiophores producing conidia from every cell; the conidia have also sprouted and bear other conidia.

FIG. 4. Development of a spore cultivated singly in a drop of nutritive fluid: *a*, the germinal tube formed; *b*, same, more fully developed and divided into cells by cross partitions; c^1, c^2, *b*, fallen pieces; c^1 and c^2 have produced conidia, *d d*, which, fallen from c^2, develop other conidia or yeast-like forms by continuing budding.

FIG. 5. Conidia forming filaments in an exhausted nutritive solution: *a*, thread full of protoplasm; *b*, filament partly emptied of protoplasm; *c*, conidia germinating while still attached together.

FIG. 6. A conidium which in germinating has protruded into air and apparently formed aerial conidia.

FIG. 7. Conidia which did not germinate to form filaments and in which oil globules have appeared; resembling spore formation.

PLATE XVI.

INDIAN CORN RUST (PUCCINIA MAYDIS).

FIG. 1. Transverse section of corn leaf through a cluster of teleutospores, showing also the ruptured epidermis and mycelial filaments among the leaf cells.

FIG. 2. Uredospores, three viewed in optical sections showing germ pores and thickness of wall; a fourth showing surface view.

FIG. 3. Teleutospores.

PLATE XVII.

ERINOSE.

FIG. 1. Lower surface of leaf attacked by Erinose. (After Corda.)

FIG. 2. Cross-section of grape leaf through one of the galls of *Phytoptus vitis*, showing the hairs (*a*) formed from prolonged epidermal cells, two of the animals (*b b*), and one of the parthenogenetic eggs (*c*). (E. A. S., del.)

THE HATCH LITHO CO. N. Y.

STRAWBERRY LEAF BLIGHT.

GEO. MARX. FECIT THE HATCH LITHO CO N Y

APPLE SCAB
Fusicladium dentriticum.

BITTER-ROT OF APPLES. LEAF-RUST OF CHERRY. BEET-RUST.

R. COWING. THE HATCH LITHO. CO. N. Y.

COTTON - LEAF BLIGHT.

(Cereospora gossypina, Cke)

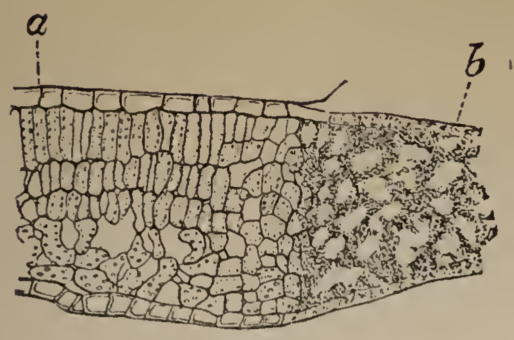
P. COWING THE HATCH LITHO. CO. N. Y.

ANTHRACNOSE OF THE BEAN

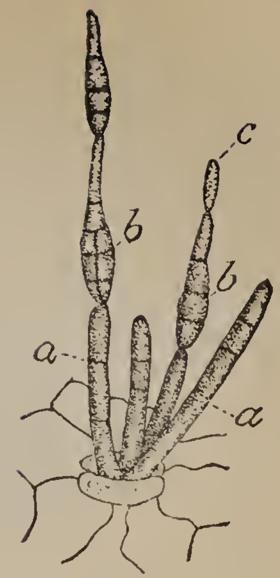
R. COWING

THE HATCH LITHO CO. N. Y.

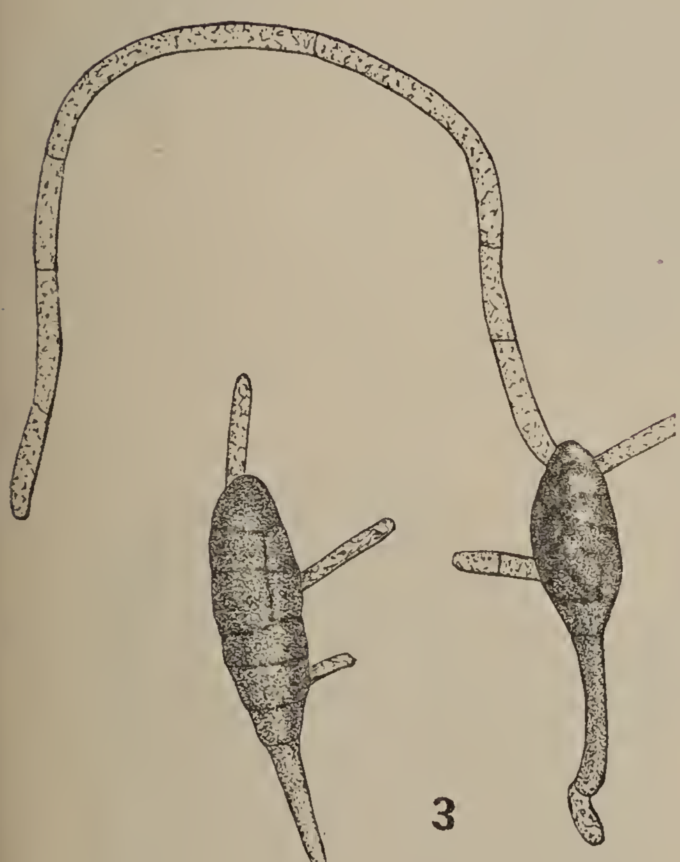
ANTHRACNOSE OF THE BEAN



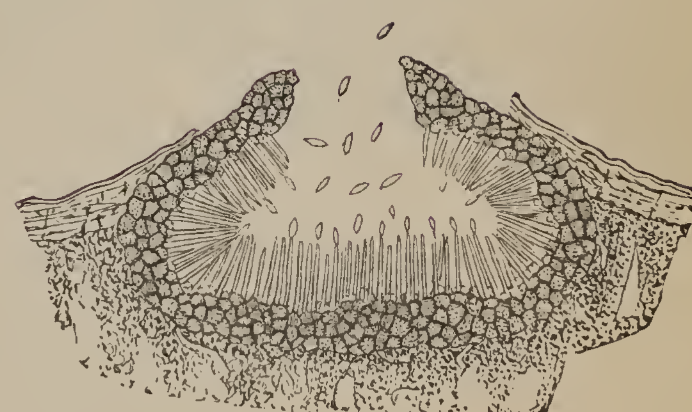
1



2



3



4

5

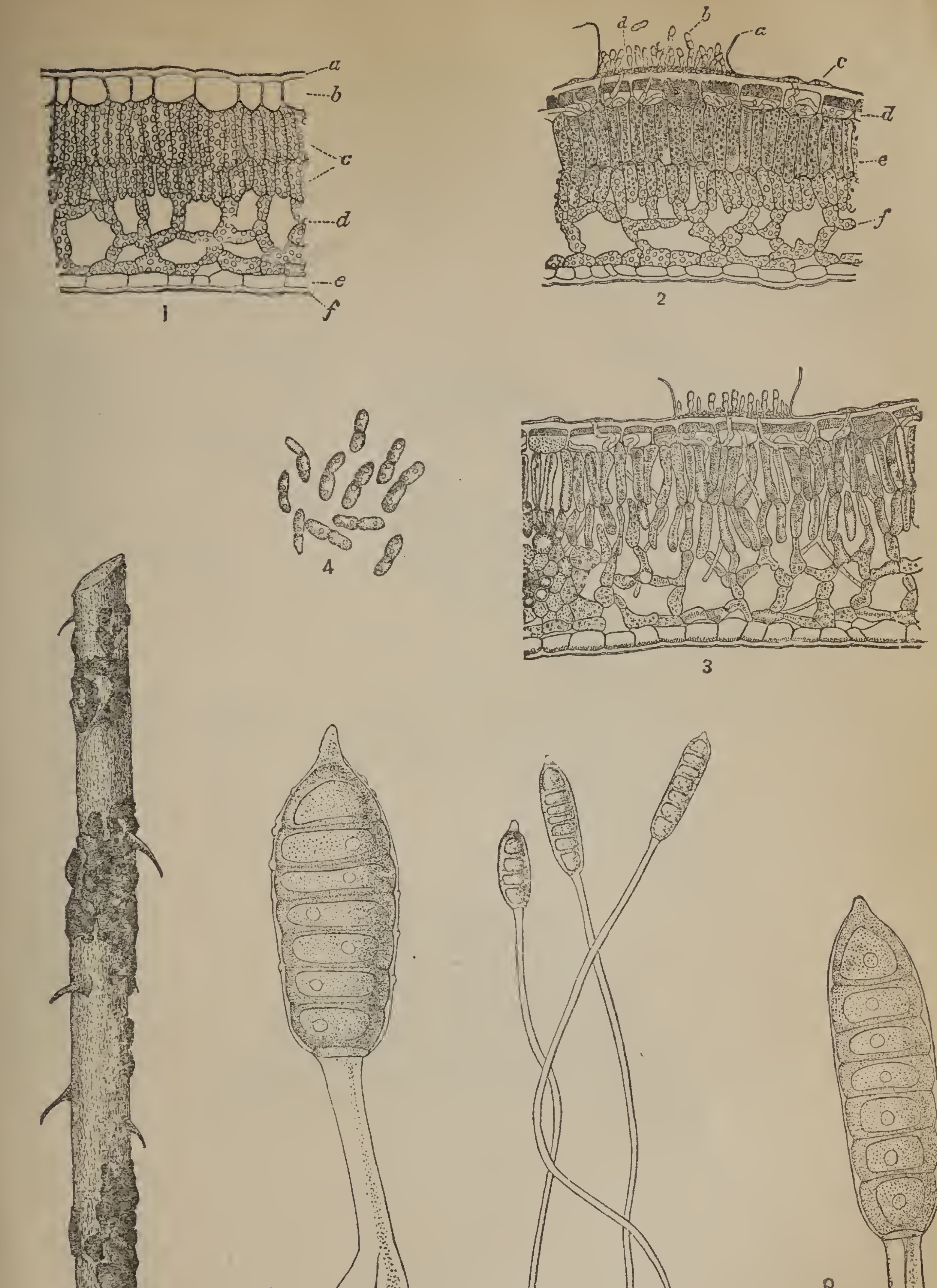
6

E. A. S. del.

LEAF-SPOT DISEASE OF CATALPA.

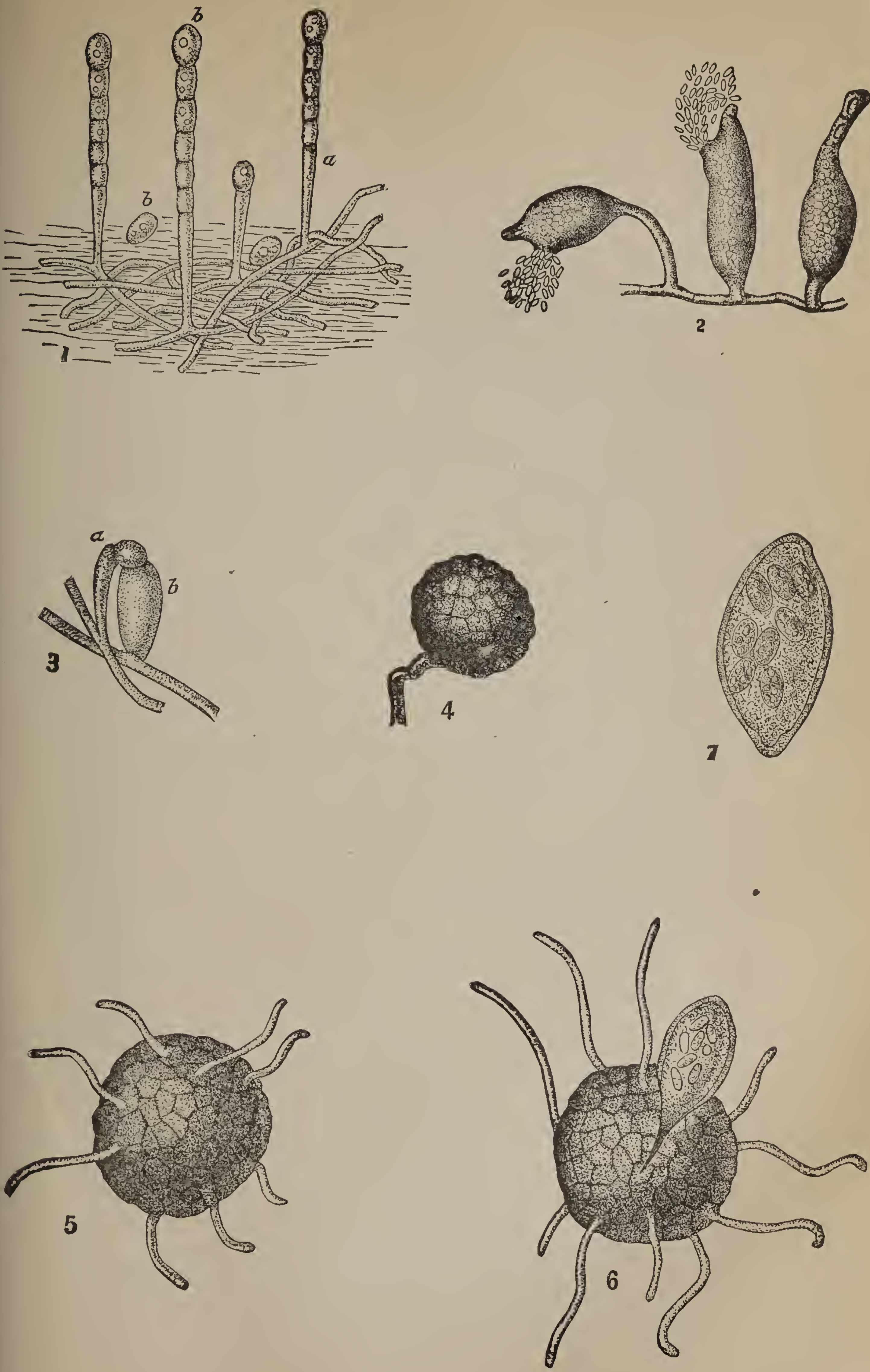
THE HATCH LITHO CO N Y

BLACK SPOT OF THE ROSE
(Actinonema rosae.)



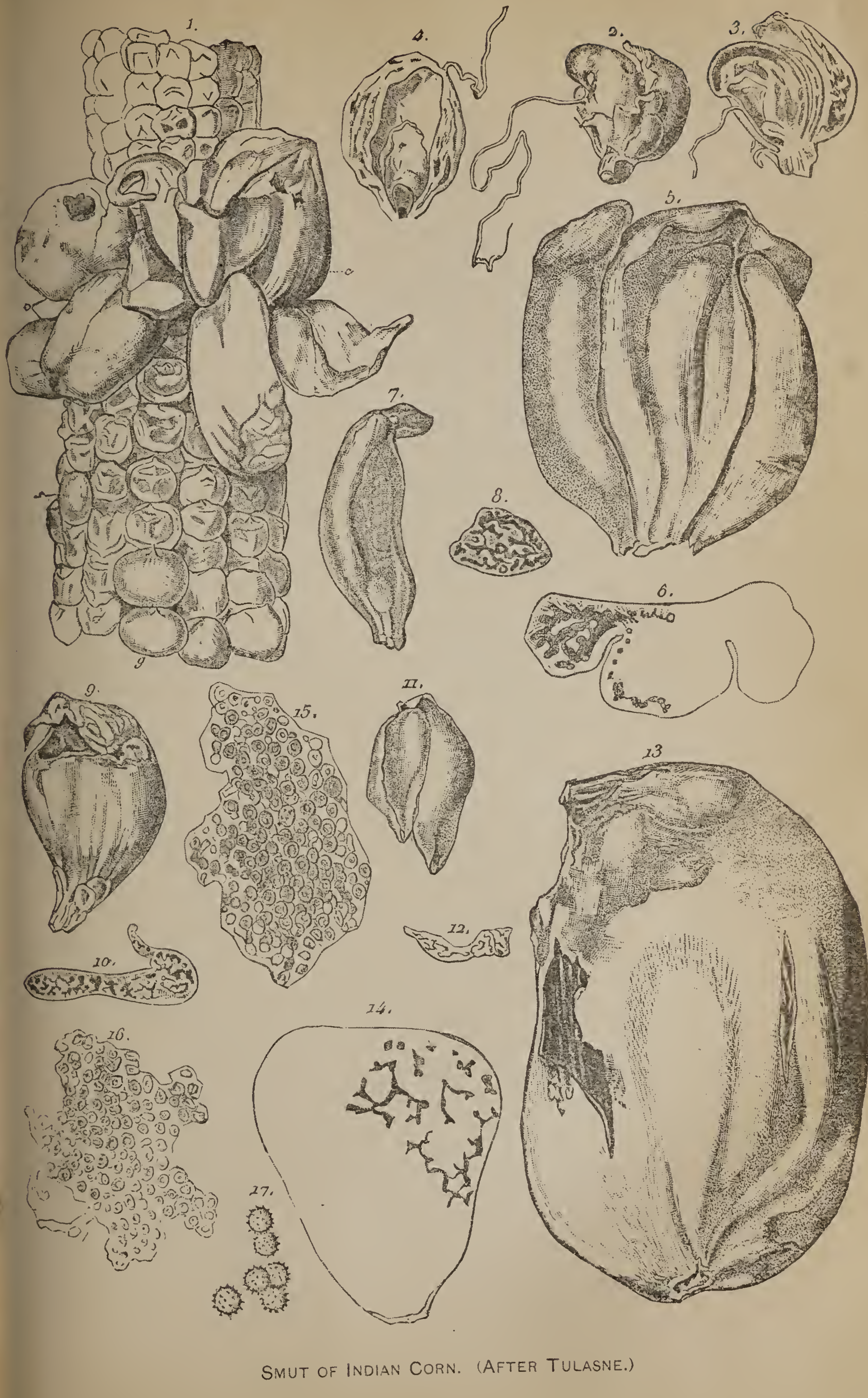
BLACK-SPOT OF ROSE AND ROSE PHRAGMIDIUM.

ROSE RUST.
(Phragmidium mucronatum)

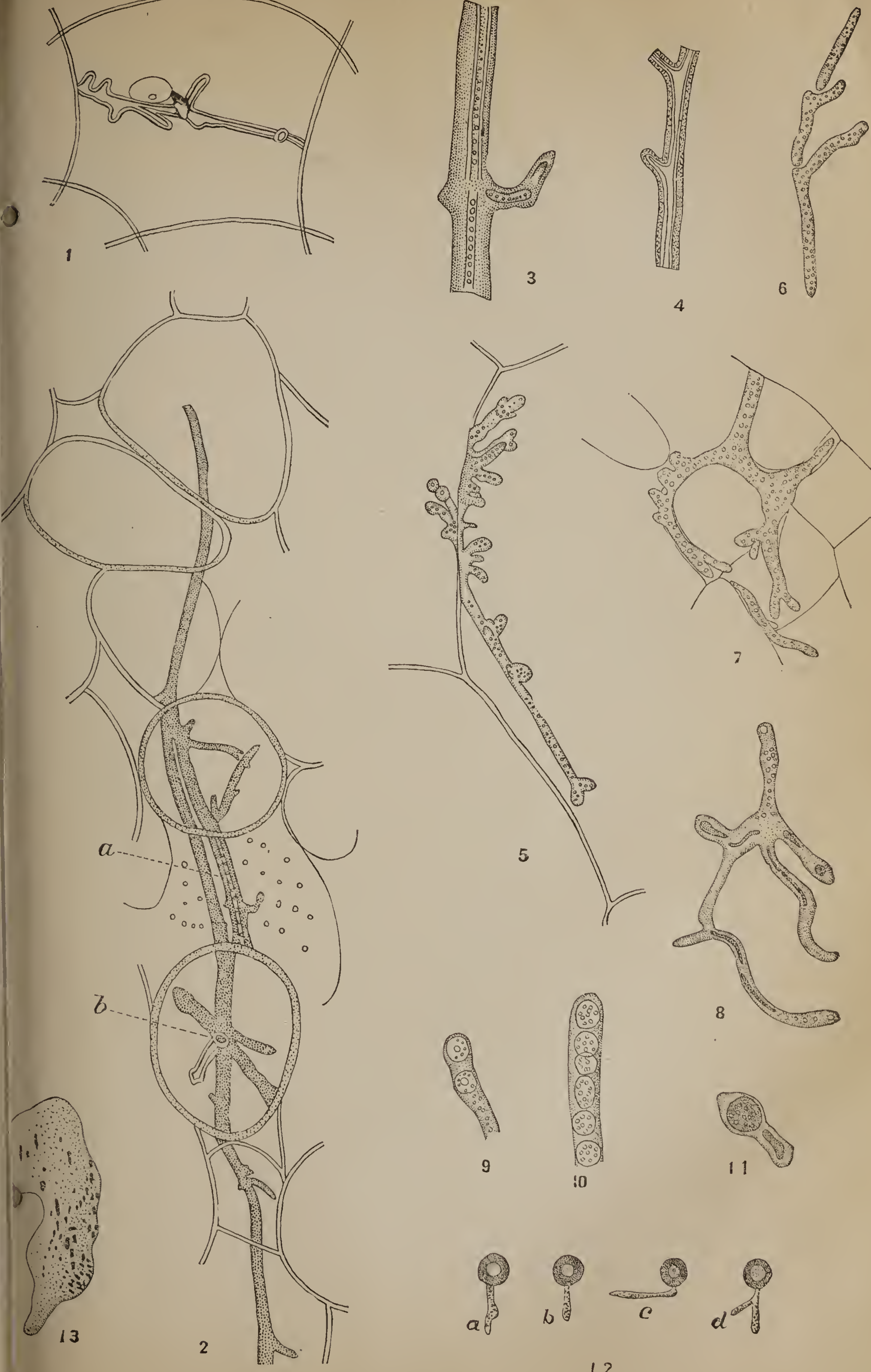


POWDERY MILDEW OF THE GOOSEBERRY.

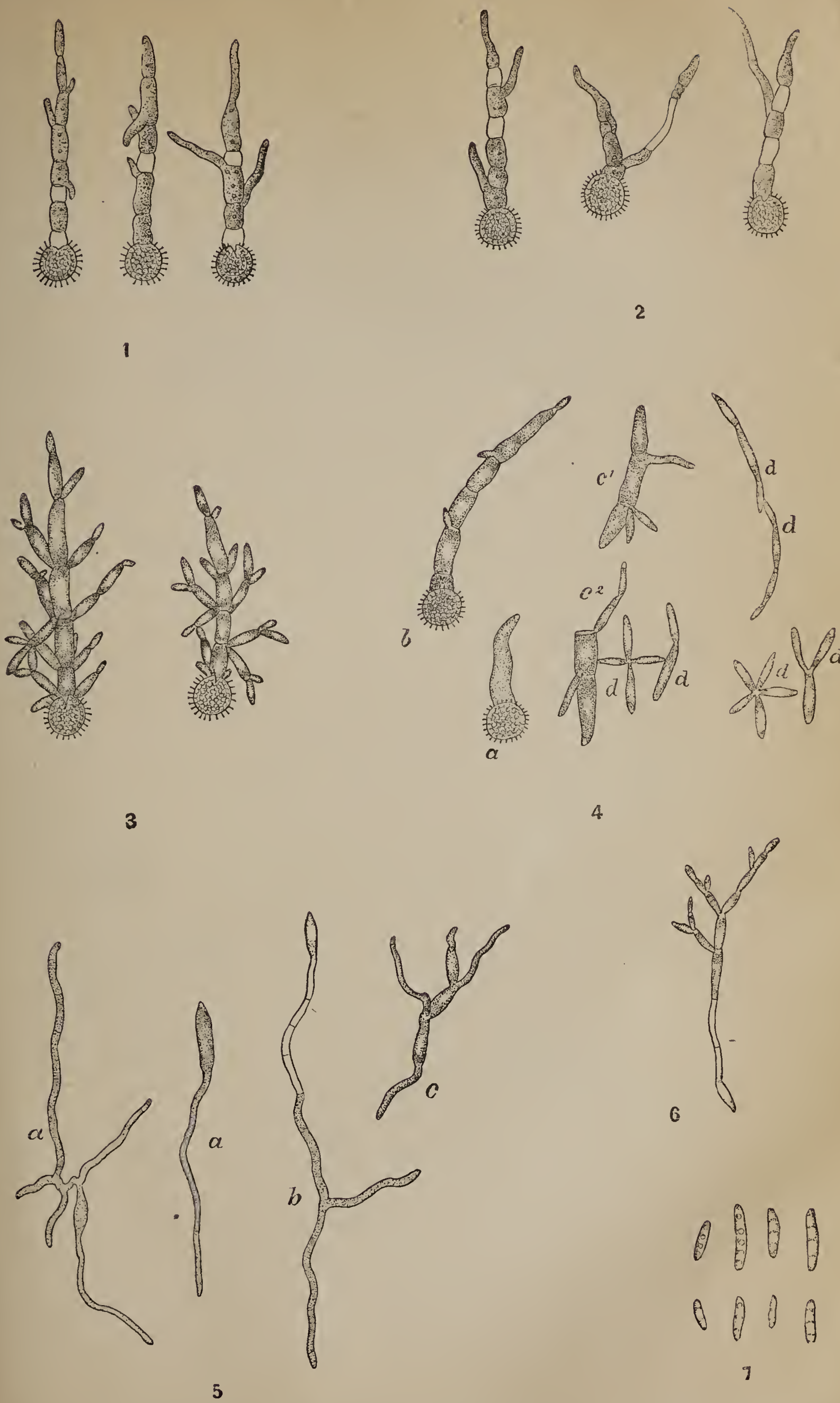
SMUT OF INDIAN CORN (USTILAGO ZEÆ-MAYS).
From photograph.



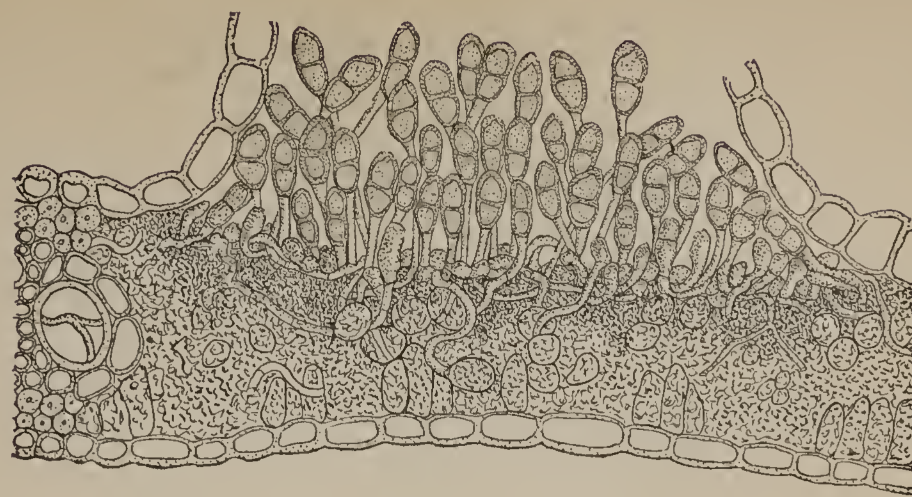
SMUT OF INDIAN CORN. (AFTER TULASNE.)



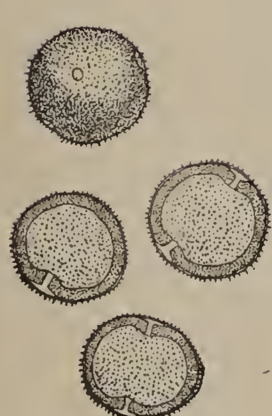
SMUT OF INDIAN CORN—MYCELIUM AND SPORE-FORMATION.



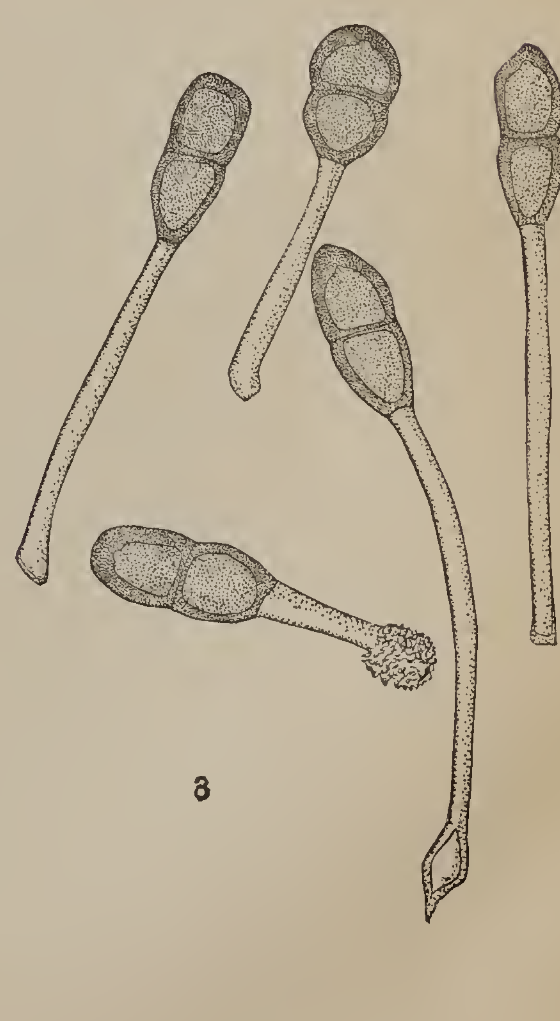
SMUT OF INDIAN CORN—GERMINATION OF SPORES IN WATER AND NUTRITIVE SOLUTIONS.
(AFTER BREFELD.)



1



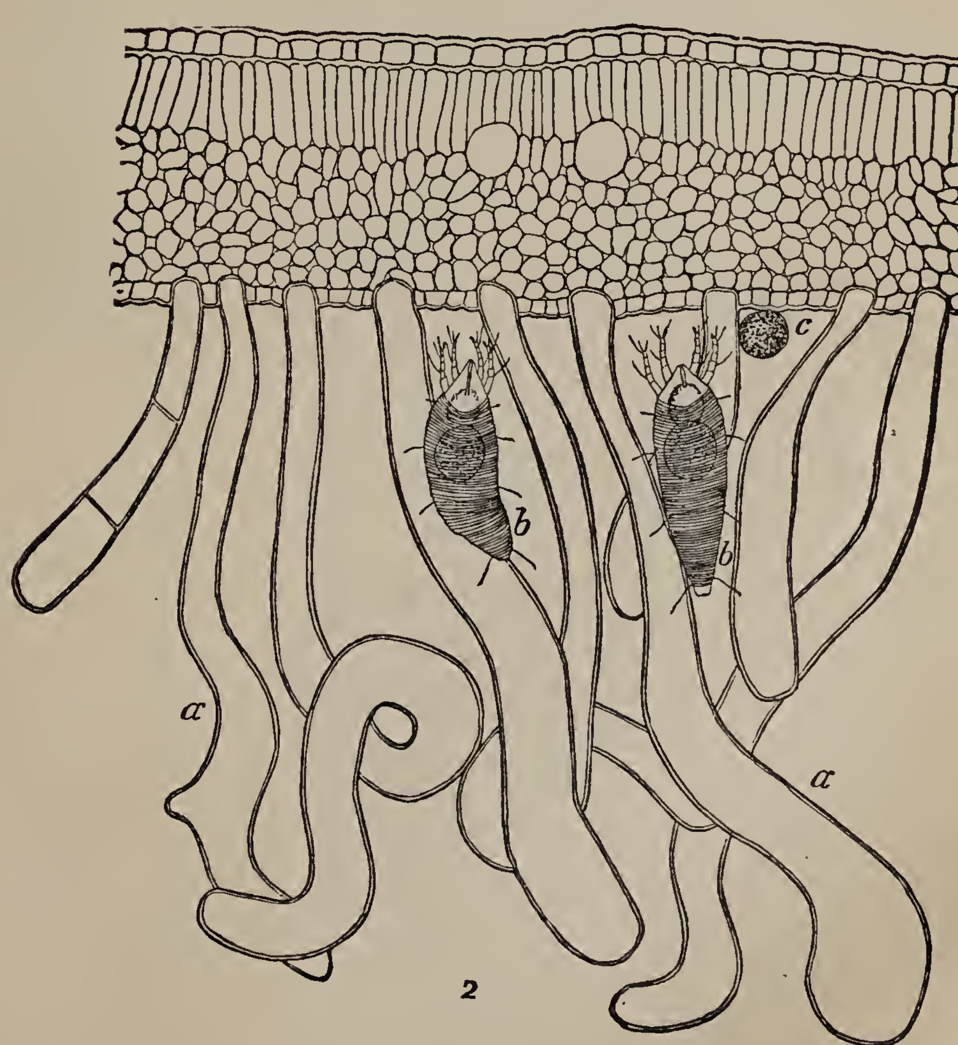
2



3

INDIAN CORN RUST.

1



2

ERINOSE.